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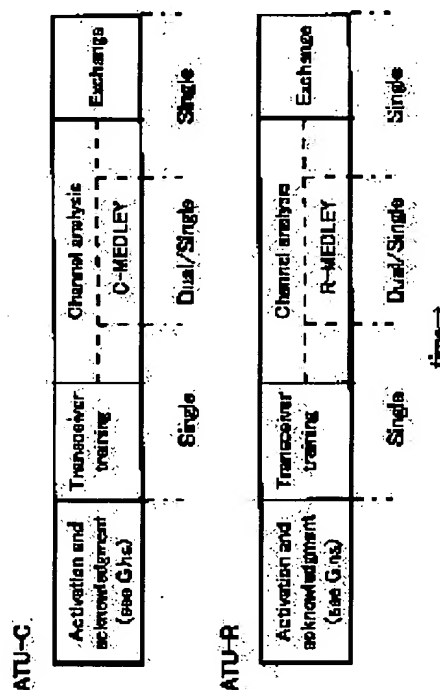
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## (54) DIGITAL SUBSCRIBER LINE TRANSMISSION SYSTEM

## (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a concrete training method in an ADSL(asymmetric digital subscriber line) transceiver at adopting of the effective transmission technique of ADSL signals under a noise environment from TCM-ISDN or a digital subscriber line transmission system, which is provided with a means for executing such a training method and communication equipment used for it.

**SOLUTION:** This digital subscriber line transmission system in which telephone line is a transmission line is provided with a training means for performing initialization by a single bit map when channel analysis is performed excluding transceiver training, exchange, C medley and R medley and checking line quality by both an inside symbol and an outside symbol when it is a dual bit map and by only the inside symbol, when it is a signal bit map in the case of performing the channel analysis of only the C medley and the R medley.



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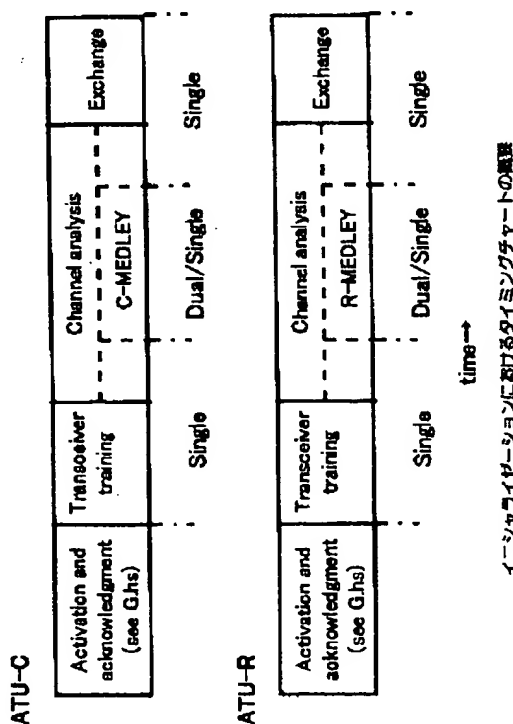
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(54) 【発明の名称】 デジタル加入者線伝送システム

(57) 【要約】

【課題】 TCM-ISDNからのノイズ環境下におけるADSL信号の有効な伝送技術を採用するに当たっての、ADSLトランシーバにおける具体的なトレーニング方法、あるいはそのようなトレーニング方法を実施する手段を備えたデジタル加入者線伝送システム及びこれに用いられる通信装置を提供すること。

【解決手段】 電話回線を伝送路とするデジタル加入者線伝送システムにおいて、トランシーバ・トレーニング、エキステンジ、Cメドレ、及びRメドレを除いたチャネルアナリシスを行う場合は、シングルビットマップでイニシャライゼーションを行い、Cメドレ及びRメドレのみの前記チャネルアナリシスを行う場合、デュアルビットマップ時はインサイド・シンボル、アウトサイド・シンボルの両方で、シングルビットマップ時はインサイド・シンボルのみで回線品質の調査を行うトレーニング手段をを備える。



## 【特許請求の範囲】

【請求項1】電話回線を伝送路とするデジタル加入者線伝送システムにおいて、

トランシーバ・トレーニング、エクステンジ、Cメドレ、及びRメドレを除いたチャネルアナリシスを行う場合は、シングルビットマップでイニシャライゼーションを行い、

Cメドレ及びRメドレのみの前記チャネルアナリシスを行う場合、

デュアルビットマップ時はインサイド・シンボル、アウトサイド・シンボルの両方で、

シングルビットマップ時はインサイド・シンボルのみで回線品質の調査を行うトレーニング手段を有したことを特徴とするデジタル加入者線伝送システム。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は、既設の電話回線を高速データ通信回線として利用するデジタル加入者線伝送システムに関し、特に上記伝送システムに供される伝送装置の変復調方式の改良に関する。近年、インターネット等のマルチメディア型サービスが一般家庭を含めて社会全体へと広く普及してきており、このようなサービスを利用するための経済的で信頼性の高いデジタル加入者線伝送システムの早期提供が強く求められている。

## 【0002】

【従来の技術】[1] ADSL技術の説明

既設の電話回線を高速データ通信回線として利用するデジタル加入者線伝送システムを提供する技術としては、xDSL (Digital Subscriber Line)が知られている。xDSLは電話回線を利用した伝送方式で、かつ、変復調技術の一つである。このxDSLは、大きく分けて加入者宅（以下、加入者側と呼ぶ。）から収容局（以下、局側と呼ぶ）への上り伝送速度と、局側から加入者側への下り伝送速度が対称のものと、非対称のものに分けられる。

【0003】非対称型のxDSLにはADSL (Asymmetric DSL)があり、下り伝送速度が6Mビット/秒程度のG. DMTと1.5Mビット/秒程度のG. Liteがあるが、どちらも変調方式としてDMT (Discrete Multiple Tone) 変調方式を採用している。

## [2] DMT変調方式の説明

DMT変調方式をG. Liteを例にとり、図11を用いて説明する。また、本説明および説明図は局から加入者への下り方向の変復調についてのみ記す。

【0004】まず、装置に送信データが入力されSerial to Parallel Buffer 10に1シンボル時間(1/4kHz)分ストアされる。ストアされたデータは送信ビットマップ60(後述)で前もって決められたキャリア当たりの伝送ビット数毎に分割して、Encoder 20に出力

する。Encoder 20では入力されたビット列をそれぞれ直交振幅変調するための信号点に変換してIFFT30に出力する。IFFT30は逆高速フーリエ変換を行うことでそれぞれの信号点について直交振幅変調を行い、Parallel to Serial Buffer 40に出力する。ここで、IFFT出力の240~255ポイントの16ポイントをCyclic PrefixとしてDMTシンボルの先頭に加える。Parallel to Serial Buffer 40からD/A Converter 50へ1.104MHzのサンプリング周波数でアナログ信号に変換され、メタリック回線100を経由して加入者側に伝送される。

【0005】加入者側では、A/D Converter 110により、1.104MHzのデジタル信号に変換され、Serial to Parallel Buffer 120に1DMTシンボル分ストアされる。同BufferでCyclic Prefixが除去され、FFT130に出力される。FFT130では高速フーリエ変換を行い、信号点を発生(復調)する。復調した信号点はDecoder 140により送信ビットマップ60と同じ値を保持している受信ビットマップ160に従ってデコードする。デコードしたデータはParallel to Serial Buffer 150にストアされ、ビット列として受信データとなる。

## [3] ビットマップの詳細説明

DMT変調方式で記したビットマップについて、図12を用いて、より詳細に説明する。

【0006】局側の装置と加入者側の装置は、通信を行うためのトレーニング時に回線の変調信号とノイズの比(以下、S/Nと呼ぶ。)を測定し、各変調キャリアで伝送するビット数を決定する。図12に示すように、S/Nが大きいキャリアでは伝送ビット数を多く割り当て、S/Nが小さいところでは伝送ビット数を少なく割り当てる。

【0007】これにより、受信側では測定したS/Nから、キャリア番号に対応した伝送ビット数を示すビットマップが作成される。受信側ではこのビットマップをトレーニング中に送信側に通知することで、定常のデータ通信時に送受信側とも同じビットマップを用いて変復調を行うことが可能となる。

## [4] ISDNピンポン伝送からの漏話対策

ISDNピンポン伝送からの漏話(以下、TCM Cross-talkと呼ぶ。)がある場合に、ADSLでは前述のビットマップを2個使用することで伝送特性を向上しようとしていた。このビットマップを2個使用する方法を図13を用いて説明する。

【0008】ISDNピンポン伝送では、図13に示す400Hzに同期して、局側が400Hzの前半のサイクルで下りデータを送信し、加入者側は下りデータ受信後、上りデータを送信する。このため、局側のADSLでは400Hzの前半のサイクルでISDNからの近端漏話(以下、NEXTと呼ぶ。)の影響を受け、後半の

サイクルで加入者側ISDNの上りデータからの遠端漏話(以下、FEXTと呼ぶ。)の影響を受ける。

【0009】加入者側ADSLでは、局側とは逆に400Hzの前半でFEXTの影響を受け、後半のサイクルでNEXTの影響を受ける。局と加入者の間のメタリックケーブルが長くなると、受信信号とNEXTとのS/Nが小さくなり、場合によっては受信信号よりもNEXTのほうが大きくなる。

【0010】この場合でもFEXTの影響はあまりないことから、従来はNEXT区間受信用のビットマップ(DMTシンボルA)と、FEXT区間受信用のビットマップ(DMTシンボルB)を2個用意して、NEXT区間では伝送ビット数を小さくして、S/N耐力を向上し、FEXT区間で伝送ビット数を大きくして、伝送容量を大きくする手法を採っていた。

【0011】また、このとき、400HzのTCM Cross-talkの周期に合わせるため、本来なら16ポイントのCyclic Prefixで1DMTシンボル当たり246μSであるのに対し、Cyclic Prefixを20ポイントとして、1DMTシンボル当たり250μSとし、TCM Cross-talkの1周期とDMTシンボル10個分の時間を合わせてTCM Cross-talkに同期していた。

【5】 FEXT およびNEXT

図1にADSLがTCM-ISDNから受けるクロストークについてのタイミングチャートを示す。

【0012】TCM-ISDNは400[Hz]の周波数で動作し、その周期は2.5[ms]である。TCM-ISDN1周期のうち、前半の半周期はCO側が送信し、後半の半周期はRT側が送信する。したがって、TCM-ISDN1周期のうち、前半の半周期において、局側ADSL装置(ATU-C)はTCM-ISDNから近端漏話(以下、NEXT: near end cross-talk)の影響を受け、後半の半周期において、TCM-ISDNから遠端漏話(以下、FEXT: far end cross-talk)の影響を受ける。一方では、TCM-ISDN1周期のうち、前半の半周期において、加入者側ADSL装置(ATU-R)はTCM-ISDNからFEXTの影響を受け、後半の半周期において、TCM-ISDNからNEXTの影響を受ける。本明細書では、このようなNEXT、FEXTの影響を受ける時間領域をそれぞれNEXT区間、FEXT区間と呼ぶ。

【0013】局側ADSL装置(ATU-C)は加入者側ADSL装置(ATU-R)におけるFEXT区間およびNEXT区間を推定(define)することができる。また、加入者側ADSL装置(ATU-R)も同様に局側ADSL装置(ATU-C)におけるFEXT区間およびNEXT区間を推定することができる。そして、それぞれの区間を以下のように定義する。

FEXT: ATU-Cが推定したATU-RにおけるFEXT区間

NEXT: ATU-Cが推定したATU-RにおけるNEXT区間

FEXTC: ATU-Rが推定したATU-CにおけるFEXT区間

NEXTC: ATU-Rが推定したATU-CにおけるNEXT区間

なお、上記定義には伝送遅延も考慮されている。

【6】スライディング・ウィンドウ

上記したようなTCM-ISDNからのクロストーク環境のもとで、ADSL信号を良好に伝送し得るデジタル加入者線伝送システムを提供することを目的に、本出願人は先に特願平10-144913号によって「スライディング・ウィンドウ」の導入を提案した。

【0014】上記特願平10-144913号によれば、局側ADSL装置(ATU-C)から加入者側ADSL装置(ATU-R)へとADSL信号を送信する下り方向の場合、TCM-ISDNからのクロストーク環境のもとで局側ADSL装置(ATU-C)が送信するADSL信号の状態を以下のように定めるものである。すなわち、図2に示すように、送信シンボルが完全にFEXT区間内に含まれる場合、スライディング・ウィンドウにより、局側ADSL装置(ATU-C)はそのシンボルをインサイド・シンボルとして送信する。また、送信シンボルが一部でもNEXT区間に含まれる場合、局側ADSL装置(ATU-C)はそのシンボルをアウトサイド・シンボルとして送信する。

【0015】また、局側ADSL装置(ATU-C)はFEXT区間用ビットマップであるビットマップAを用いてインサイド・シンボルを送信し、NEXT区間用ビットマップであるビットマップBを用いてアウトサイド・シンボルを送信する(Dual Bitmap)。下りと同様に、上りにおいて、加入者側ADSL装置(ATU-R)はFEXTC区間用ビットマップであるビットマップAを用いてインサイド・シンボルを送信し、NEXTC区間用ビットマップであるビットマップBを用いてアウトサイド・シンボルを送信する。

【0016】ここで、局側ADSL装置(ATU-C)はビットマップBを用いない場合がある(Single Bitmap)。このとき、局側ADSL装置(ATU-C)はスライディング・ウィンドウの外側において、パイロット・トーンのみを送信する。同様に加入者側ADSL装置(ATU-R)もビットマップBを用いない場合があり、加入者側ADSL装置(ATU-R)はスライディング・ウィンドウの外側では何も送信しない。

【0017】

【発明が解決しようとする課題】以上説明したように、TCM-ISDNからのノイズ環境下における有効なADSLの伝送技術については、例えば本出願人によってなされた上記特願平10-144913号によって提供されるものであるが、このような伝送技術を採用するに当たってのADSLトランシーバにおける具体的なトレーニング方法、あるいはそのようなトレーニング方法を実施する手段といった点については、未だ検討の余地が残されている。

【0018】本発明は、上記のような点についての新たな知見と考察に基づいてなされたものであり、TCM-ISDNからのノイズ環境下におけるADSL信号の有効な伝送技術を採用するに当たっての、ADSLトランシーバにおける具体的なトレーニング方法、あるいはそのようなトレーニング方法を実施する手段を備えたデジタル加入者線伝送システム及びこれに用いられる通信装置を提供するこ

とを目的とするものである。

【0019】

【課題を解決するための手段】本発明の第1の側面によれば、電話回線を伝送路とするディジタル加入者線伝送システムにおいて、トランシーバ・トレーニング (Transceiver training)、エクスチェンジ (Exchange)、Cメドレ (C-MEDLEY)、及びRメドレ (R-MEDLEY)を除いたチャンネルアナリシス (Channel analysis)を行う場合は、シングルビットマップ (Single Bitmap) でイニシャライゼーションを行い、Cメドレ (C-MEDLEY)及びRメドレ (R-MEDLEY)のみの前記チャンネルアナリシスを行う場合、デュアルビットマップ (Dual Bitmap) 時はインサイド・シンボル、アウトサイド・シンボルの両方で、シングルビットマップ (Single Bitmap) 時はインサイド・シンボルのみで回線品質の調査を行うトレーニング手段を有したことを特徴とするディジタル加入者線伝送システムが提供される。

【0020】一方、本発明の第2の側面によれば、局側ADSL装置 (ATU-C)、加入者側ADSL装置 (ATU-R)それぞれが独立したカウンタを有し、ハイパーフレームカウンタ (501) がDMTシンボルクロック (519) を連続して所定回数 (例えば345回) カウントすることでDMTシンボルの数をカウントする機能を有したことを特徴とするディジタル加入者線伝送システムが提供される。

【0021】また、本発明の第3の側面によれば、上記第2の構成において、カウンタのカウント値を用いてスライディングウィンドウDEC (503)によりスライディング・ウィンドウのFEXTR、NEXTR、FEXTC、NEXTCの区間の特定を行う手段 (523) を有したことを特徴とするディジタル加入者線伝送システムが提供される。また、本発明の第4の側面によれば、センタ側ADSL装置 (ATU-C) ではC-REVEILLE、C-RATES1の開始にあたり、加入者側ADSL装置 (ATU-R) ではR-REBERB3の開始を400Hzの位相に合わせるため、400Hz信号 (517) をシーケンスの遷移条件とする手段 (507) と、そのときにハイパーフレームカウンタ (501) をクリアする手段を有したことを特徴とするディジタル加入者線伝送システムが提供される。

【0022】また、本発明の第5の側面によれば、シンボル数カウンタ (505) は、DMTシンボルクロック (519) をカウントすることでDMTシンボルの数をカウントし、カウント値DEC (513) の値と一致したこと (509) をシーケンスの遷移条件とすること (507) とで各イニシャライズ信号の長さを決定する手段を有したことを特徴とするディジタル加入者線伝送システムが提供される。

【0023】また、本発明の第6の側面によれば、外部からの受信信号検出信号やCRC演算結果などのシーケンス遷移情報 (521) を遷移条件論理 (507) とし、シーケンスカウンタ (511) のイネーブル信号とすることで、シーケンスカウンタ (511) のカウント値がイニシャライズシーケンスの状態を表すコード値となり、シーケンスカウ

ンタ (511) のカウント値を用いてイニシャライズDECにより、送信するイニシャライズ信号 (C-REVEILLE、C-PILOT1、C-REVERB1 など) を決定するイニシャライズ情報 (525) を作成する手段を有したことを特徴とするディジタル加入者線伝送システムが提供される。

【0024】また、本発明の第7の側面によれば、Transceiver trainingにおいて、上記第1の構成とは異なり、デュアルビットマップ (Dual Bitmap) でイニシャライゼーションを行うことがあれば、FEXT区間でのみトレーニングを行う手段を有したことを特徴とするディジタル加入者線伝送システムが提供される。また、本発明の第8の側面によれば、TEQおよびFEQトレーニングにおいては、NEXT区間において、TEQおよびFEQの係数更新用ステップサイズを0、または非常に小さい値にすることにより、FEXT区間およびNEXT区間問わず、連続してトレーニングを行う手段を有したことを特徴とするディジタル加入者線伝送システムが提供される。

【0025】また、本発明の第9の側面によれば、1つのハイパー・フレーム中に1つのインバース・シンクロナイゼーション・シンボル (I) があるが、各トレーニングにおいては、このインバース・シンクロナイゼーション・シンボル (I) もシンクロナイゼーション・シンボル (S) と併せて使用する手段を有したことを特徴とするディジタル加入者線伝送システムが提供される。

【0026】また、本発明の第10の側面によれば、上記第9の構成において、受信側でインバース・シンクロナイゼーション・シンボル (I) が受信されたら、図12に示されているFFT (130) の後でパイロット・トーンを除く各キャリアの位相を180度回転させることにより、シンクロナイゼーション・シンボル (S) を受信したときと同じ状態とし、その後、受信側で生成したシンクロナイゼーション・シンボル (S) を用いてトレーニングを行う手段を有したことを特徴とするディジタル加入者線伝送システムが提供される。

【0027】また、本発明の第11の側面によれば、上記第9の構成において、フレーム同期のための位相検出においては、シンクロナイゼーション・シンボル (S) を用いて位相検出を行った場合、次のインバース・シンクロナイゼーション・シンボル (I) で確認を行い、また、インバース・シンクロナイゼーション・シンボル (I) を用いて位相検出を行った場合、次のシンクロナイゼーション・シンボル (S) で確認を行う手段を有したことを特徴とするディジタル加入者線伝送システムが提供される。

【0028】また、本発明の第12の側面によれば、加入者側ADSL装置 (ATU-R) では、センタ側ADSL装置 (ATU-C) から送信された74番目のキャリアを受信してから、図12に示されるようなFFT (130) を実行し、そのFFT出力の位相により、FEXTR区間あるいはNEXTR区間を認識し、そして、その情報を用いてTCM-ISDNのバースト

同期である400 [Hz]の位相を認識する手段を有したことを特徴とするデジタル加入者線伝送システムが提供される。

【0029】また、本発明の第13の側面によれば、上記第12の構成とは異なり、加入者側ADSL装置(ATU-R)では、センタ側ADSL装置(ATU-C)から送信された74番目のキャリアを受信してから、図5に示すようにQPSK復調を行い、その結果により、FEXTR 区間あるいはNEXTR 区間を認識し、そして、その情報を用いてTCM-ISDN 400 [Hz]の位相を認識する手段を有したことを特徴とするデジタル加入者線伝送システムが提供される。

【0030】また、本発明の第14の側面によれば、図7に示すようなセンタ側ADSL装置(ATU-C)において、装置内で400 [Hz]を認識するために、外部からTCM-ISDN 400 [Hz] (702)が入力された場合、そのTCM-ISDN 400 [Hz]をセンタ側ADSL装置(ATU-C)内部の発振器(VCX0) (704)に入力して、APLL (703)で同期をとるのではなく、外部からのNTR 8 [kHz] (701)信号 (TCM-ISDN 400 [Hz]とNTR 8 [kHz]は、周波数同期が取れている)をVCX0に入力して局側ADSL装置(ATU-C)の発振周波数(704)と同期を取り、それを分周した400 [Hz] (709)を生成する手段を有したことを特徴とするデジタル加入者線伝送システムが提供される。

#### 【0031】

【発明の実施の形態】以下、図面を参照しながら本発明の一実施態様を詳述する。

#### 〔1〕イニシャライゼーション

図3にADSLトランシーバのイニシャライゼーションにおけるタイミングチャートの概要を示す。ADSLのトレーニング時では、上り、下りともTCM-ISDNへの影響を考慮し、TCM-ISDNへのNEXTノイズとならない区間のみ、ADSLの信号を送出することが重要となる。そのため、図3に示されているように、トランシーバ・トレーニング(Transceiver training)およびエクスチェンジ(Exchange)ではシングルビットマップ(Single Bitmap)でイニシャライゼーションを行う。チャネル・アナリシス(Channel analysis)についてもC メドレ(C-MEDLEY)およびR メドレ(R-MEDLEY)以外のシーケンスにおいては、シングルビットマップ(Single Bitmap)でイニシャライゼーションを行うが、C メドレ(C-MEDLEY)およびR メドレ(R-MEDLEY)のみにおいては、デュアルビットマップ(Dual Bitmap)時はインサイド・シンボル、アウトサイド・シンボルの両方で、シングルビットマップ(Single Bitmap)時はインサイド・シンボルのみで回線品質の調査(S/Nの測定)を行う。

#### 〔2〕イニシャライズカウンタ

図4に本発明のイニシャライズカウンタの実施態様を示す。

【0032】ADSLでは局側ADSL装置(ATU-C)、加入者側ADSL装置(ATU-R)それぞれ独立したカウンタを持つ。ハ

イパーフレームカウンタ(501)はDMTシンボルクロック(519)を連続して所定回数(例えば345回)カウントすることでDMTシンボルの数をカウントする機能を持ち、そのカウンタ値を用いてスライディングウィンドウDEC(503)によりスライディング・ウィンドウのFEXTR、NEXTR、FEXTC、NEXTCの区間の特定を行う(523)。

【0033】また局側ADSL装置(ATU-C)ではC-REVEILLE、C-RATES1の開始を、加入者側ADSL装置(ATU-R)ではR-REBERB3の開始を400Hzの位相に合わせるため、400Hz信号(517)をシーケンスの遷移条件とすること(507)と、そのときにハイパーフレームカウンタ(501)をクリアすることで、これを実現する。シンボル数カウンタ(505)は、DMTシンボルクロック(519)をカウントすることでDMTシンボルの数をカウントし、カウンタ値DEC(513)の値と一致したこと(509)をシーケンスの遷移条件とすること(507)とで各イニシャライズ信号の長さを決定する。また外部からの受信信号検出信号やCRC演算結果などのシーケンス遷移情報(521)を遷移条件論理(507)とし、シーケンスカウンタ(511)のイネーブル信号とすることで、シーケンスカウンタ(511)のカウント値がイニシャライズシーケンスの状態を表すコード値となり、シーケンスカウンタ(511)のカウント値を用いてイニシャライズDECにより、送信するイニシャライズ信号(C-REVEILLE、C-PILOT1、C-REVERB1など)を決定するイニシャライズ情報(525)を作成する。

【0034】この方法はハードでの実現を意識したものであるが、ソフトにおいても同様な構成で実現できる。また、C-PILOT1において、TCM-ISDN400 [Hz]の位相を局側ADSL装置(ATU-C)から加入者側ADSL装置(ATU-R)に通知し、加入者側ADSL装置(ATU-R)ではこれを検出し400Hz信号(517)とする。この方法の詳細は後述するが、これにより、加入者側ADSL装置(ATU-R)においてTCM-ISDN等の周期的なクロストーク検出が可能になる。

#### 〔3〕トランシーバトレーニング(Transceiver training)

トランシーバトレーニング(Transceiver training)にはTEQ、FEQ、AGC、タイミング再生、フレーム同期のトレーニングシーケンスが含まれている。これらについては、ADSLトランシーバが例えばシンクロナイゼーションシンボル(S)といった疑似確率信号を繰り返し送出しているときにのみ、トレーニングが行われる。一方、トランシーバトレーニング(Transceiver training)ではシングルビットマップ(Single Bitmap)でイニシャライゼーションを行うため、これらのトレーニングは必然的にFEXT区間のみで行われることになる。

【0035】ただし、トランシーバトレーニング(Transceiver training)において、デュアルビットマップ(Dual Bitmap)でイニシャライゼーションを行うことがあれば、FEXT区間でのみトレーニングを行うこともある。TEQおよびFEQ トレーニングにおいては、FEXT区間および

NEXT区間を問わず、連続してトレーニングを行うことも可能である。このとき、NEXT区間においては、TEQ およびFEQ の係数更新用ステップサイズを0、または非常に小さい値にする。

#### [4] Inverse Synchronization Symbol

図8、9に示すように、1つのハイパー・フレーム中に1つのインバースシンクロナイゼーションシンボル(I)があるが、各トレーニングにおいては、同期速度向上のため、このインバースシンクロナイゼーションシンボル(I)も以下のようにしてシンクロナイゼーションシンボル(S)と併せて使用する。

【0036】受信側でインバースシンクロナイゼーションシンボル(I)が受信されたら、図12に示されているFFT(130)の後でパイロット・トーンを除く各キャリアの位相を180度回転させる。これにより、シンクロナイゼーションシンボル(S)を受信したときと同じ状態し、その後、受信側で生成したシンクロナイゼーションシンボル(S)を用いてトレーニングを行う。フレーム同期のための位相検出においては、シンクロナイゼーション \*

\*シンボル(S)を用いて位相検出を行った場合、次のインバースシンクロナイゼーションシンボル(I)で確認を行う。また、インバースシンクロナイゼーションシンボル(I)を用いて位相検出を行った場合、次のシンクロナイゼーションシンボル(S)で確認を行う。

[5] TCM-ISDN 400 [Hz] の位相を局側ADSL装置(ATU-C)から加入者側ADSL装置(ATU-R)に通知する方法  
以下にTCM-ISDN 400 [Hz] の位相を局側ADSL装置(ATU-C)から加入者側ADSL装置(ATU-R)に通知する方法の詳細を示す。

【0037】C-PILOT1ではパイロット・トーンの他に、TCM-ISDNからのクロストークの少ない周波数帯に属する74番目(319.125 kHz)のキャリアを送信する。局側ADSL装置(ATU-C)から加入者側ADSL装置(ATU-R)にTCM-ISDN 400 [Hz] の位相の通知を、この74番目のキャリアで2ビットを使用して以下のように行う。なお、この様子は図10に示されている。

【0038】

【表1】

通知する対象	変調前ビット列	変調後の位相
FEXT <sub>R</sub> 区間(ビットマップA)	{0,0}	(++)
NEXT <sub>R</sub> 区間(ビットマップB)	{0,1}	(+-)

加入者側ADSL装置(ATU-R)は、局側ADSL装置(ATU-C)から送信された74番目のキャリアを受信し、以下の2種類の方法により、TCM-ISDN 400 [Hz] の位相を認識する。

(1) FFTを行うことで、TCM-ISDN 400 [Hz] の位相を認識する方法

加入者側ADSL装置(ATU-R)では、74番目のキャリアを受信してから、図12に示されているFFT(130)を実行する。そして、そのFFT出力の位相により、FEXT<sub>R</sub>区間あるいはNEXT<sub>R</sub>区間を認識する。そして、その情報を用いてTCM-ISDN 400 [Hz] の位相を認識する。

【0039】しかし、この方法では256ポイントごとの比較的粗い精度のみでしか加入者側ADSL装置(ATU-R)はTCM-ISDN 400 [Hz] の位相を認識することができない。そこで、より良い精度を得るためには次の方法が有効である。

(2) QPSK復調を行うことで、TCM-ISDN 400 [Hz] の位相を認識する方法

加入者側ADSL装置(ATU-R)では、74番目のキャリアを受信してから、図5に示すようにQPSK復調を行う。そして、その結果により、FEXT<sub>R</sub>区間あるいはNEXT<sub>R</sub>区間を認識する。そして、その情報を用いてTCM-ISDN 400 [Hz] の位相を認識する。

【0040】本方式では、1ポイントごとの高い精度で加入者側ADSL装置(ATU-R)はTCM-ISDN 400 [Hz] の位相を認識することが可能となる。

[6] TCM-ISDN 400 [Hz] burst clock のPLL 構成法

図6にATU-C送信器リファレンスモデルを示す。図6に示されているように、局側ADSL装置(ATU-C)装置には外部からNTR (Network Timing Reference)と呼ばれる8 [kHz] の信号が常に入力される。また、TCM-ISDN 400 [Hz] の信号も外部から入力される場合がある。TCM-ISDN 400 [Hz] の信号は、外部から入力されずに局側ADSL装置(ATU-C)装置内部で生成される場合もある(例えば、特願平10-115223号を参照のこと)。このとき、TCM-ISDN 400 [Hz] とNTR 8 [kHz] は、周波数同期が取れている。

【0041】図7に示す局側ADSL装置(ATU-C)装置において、装置内で400 [Hz]を認識するために、外部からTCM-ISDN 400 [Hz] (702)が入力された場合、そのTCM-ISDN 400 [Hz] を局側ADSL装置(ATU-C)内部の発振器(VCXO) (704)に入力して、APLL (703)で同期をとるのではなく、外部からのNTR 8 [kHz] (701)信号 (TCM-ISDN 400 [Hz] とNTR 8 [kHz] は、周波数同期が取れている) をVCXOに入力して局側ADSL装置(ATU-C)の発振周波数(704)と同期を取り、それを分周した400 [Hz] (709)を生成することを特徴とする。

【0042】まず、通常は、局側ADSL装置(ATU-C)内部のPLLにTCM-ISDN 400 [Hz] (702)を入力し、そのTCM-ISDN 400 [Hz] と内部のVCXO (704)の周波数と同期をとる。通常局側ADSL装置(ATU-C)のVCXOの発振周波数は、17.664 [MHz]程度であり、その場合は、TCM-ISDN 400 [Hz] との同期をかける場合は、44160 (17.664M/400)に

1回の位相比較情報により、PLL同期動作を行うこととなる。通常、位相比較回数が多いほど、位相ジッターや、周波数誤差は、小さくなる。しかし、17.664 [MHz]のクロックにおいて、44160回に1回の位相比較では、通常位相ジッターや周波数誤差が非常に大きくなる。

【0043】これを避けるため、TCM-ISDN 400 [Hz]に同期したNTR 8 [kHz] (701)が局側ADSL装置(ATU-C)には必ず外部から供給されているので、このNTR 8 [kHz]により局側ADSL装置(ATU-C)内部のVCXOをPLL同期動作を行えば、位相比較回数がTCM-ISDN 400 [Hz]の時より20倍増加し、2208に1回の位相比較情報が得られ、位相ジッターや周波数誤差が低減可能となる。

【0044】なお、上記の態様は本発明を実施するに当たっての一態様に過ぎず、他に幾多の変形が考慮されるが、いずれの場合においても本発明の効果が変わらないことは言うまでもない。

【0045】

【発明の効果】以上詳述したように、本発明によれば、TCM-ISDNからのノイズ環境下におけるADSL信号の有効な伝送技術を採用するに当たっての、ADSLトランシーバにおける具体的なトレーニング方法、あるいはそのようなトレーニング方法を実施する手段を備えたデジタル加入者線伝送システム及びこれに用いられる通信装置が提供されるものである。

【図面の簡単な説明】

【図1】TCM-ISDNクロストークのタイミングチャートである。

【図2】スライディング・ウィンドウを示す図である。

【図3】イニシャライゼーションにおけるタイミングチャートの概要を示す図である。

【図4】本発明のイニシャライズカウンタの実施態様を示す図である。

【図5】QPSK復調を示す図である。

【図6】ATU-C送信機リファレンスモデルを示す図である。

【図7】ATU-Cタイミング再生アルゴリズムを示す図である。

【図8】SWB方式の局側伝送パターンを示す図である。

【図9】SWB方式の加入者側伝送パターンを示す図である。

【図10】DMTシンボル毎の送信パターンを示す図である。

【図11】ビットマップを2個使用する場合のSWB方式を示す図である。

【図12】DMT変調方式による加入者伝送システムの機能ブロックを示す図である。

【図13】ビットマップの定義を示す図である。

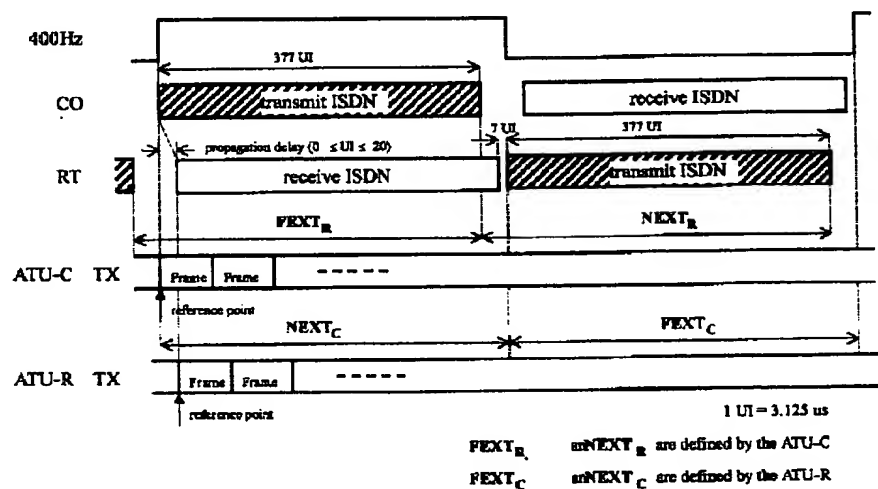
【図14】従来例を示す図である。

【符号の説明】

- 501 ... ハイパーフレームカウンタ
- 503 ... スライディングウィンドウDEC
- 505 ... シンボル数カウンタ
- 507 ... 遷移条件論理
- 511 ... シーケンスカウンタ
- 517 ... 400Hz 信号
- 519 ... DMTシンボルクロック
- 521 ... シーケンス遷移情報
- 525 ... イニシャライズ情報

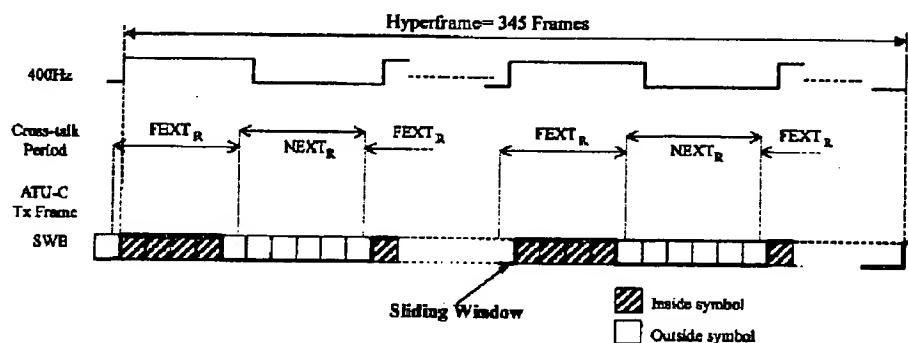
30

【図1】



TCM-ISDNクロストークのタイミングチャート

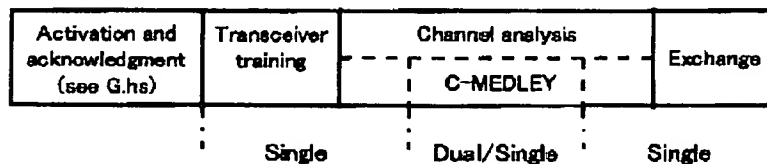
【図 2】



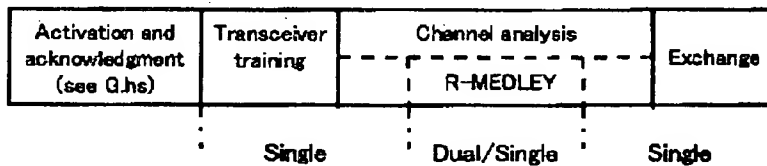
スライディング・ウィンドウ

【図 3】

ATU-C



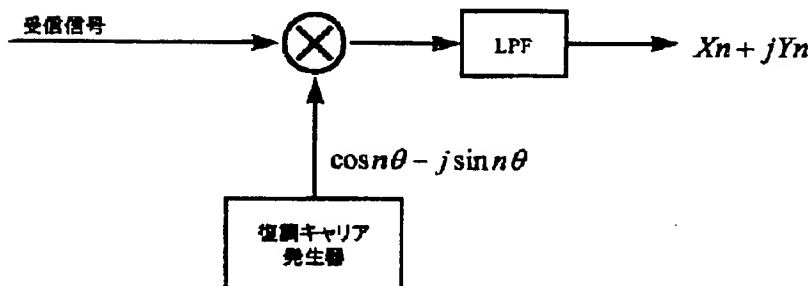
ATU-R



time→

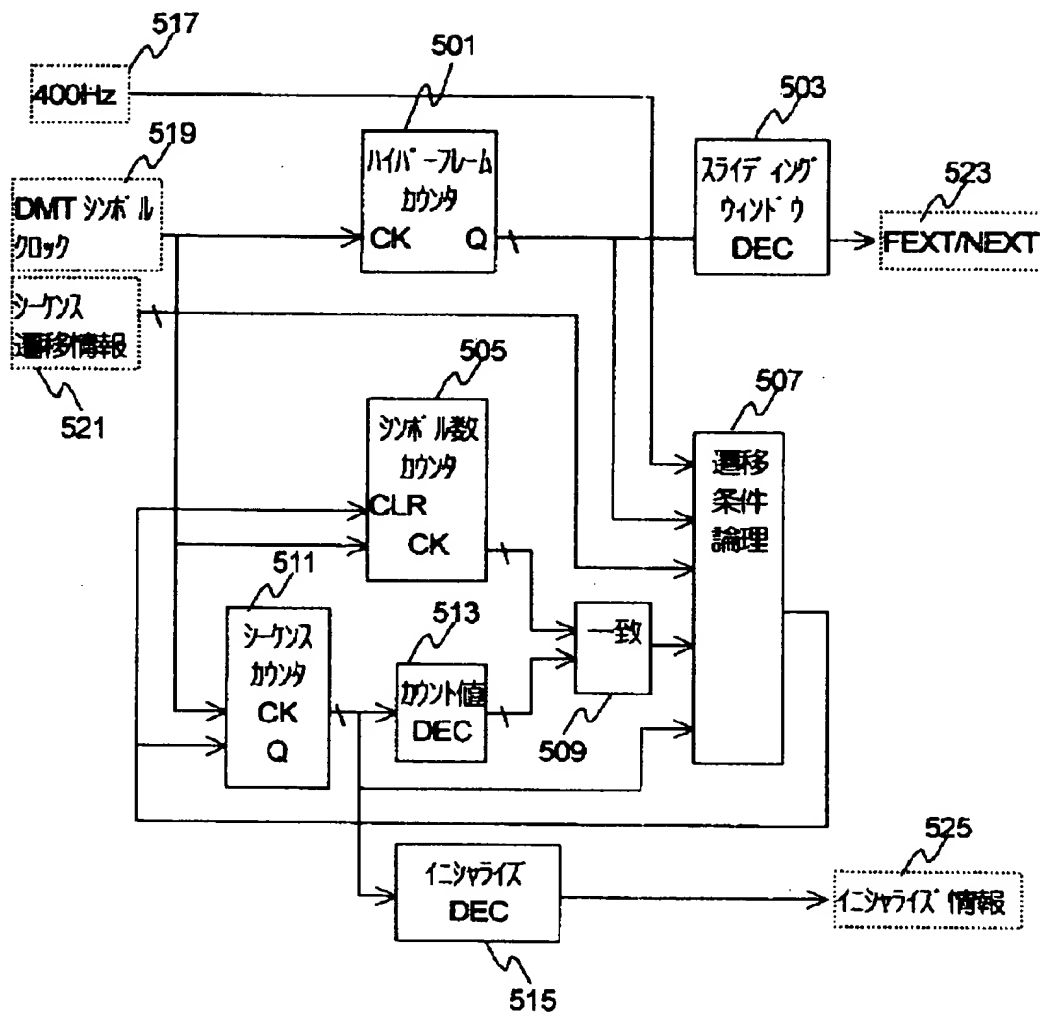
イニシャライゼーションにおけるタイミングチャートの概要

【図 5】



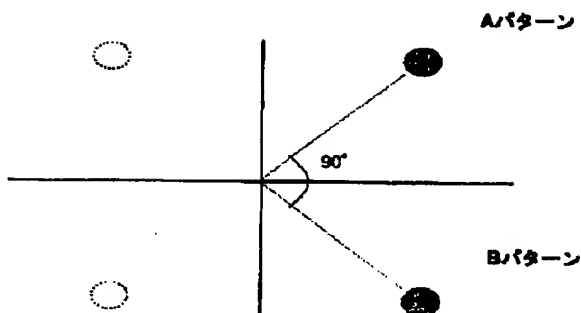
GPSK 復調

【図4】



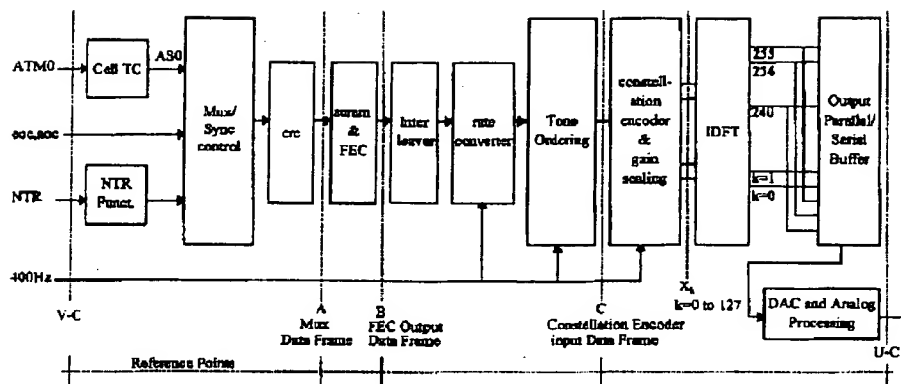
本発明の初期値カウンタの実施態様

【図10】



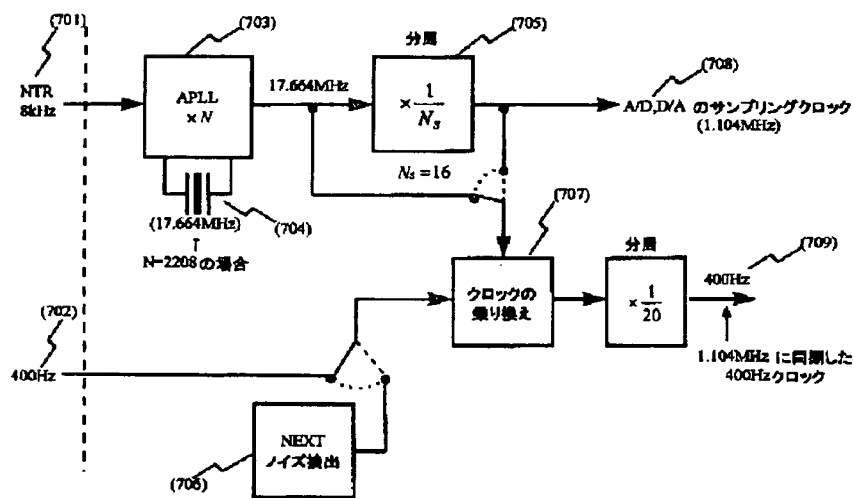
DMTシンボル毎の送信パターン

【図 6】



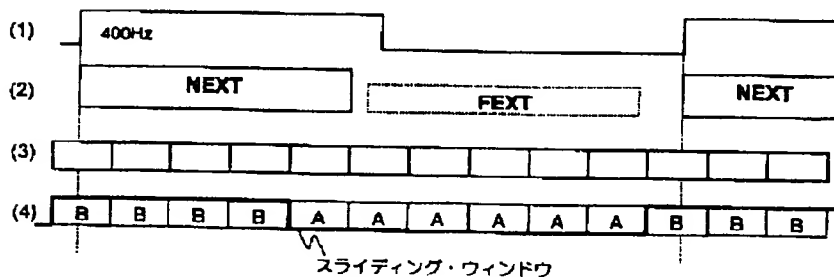
## ATU-C 送信機リファレンスモデル

【图 7】



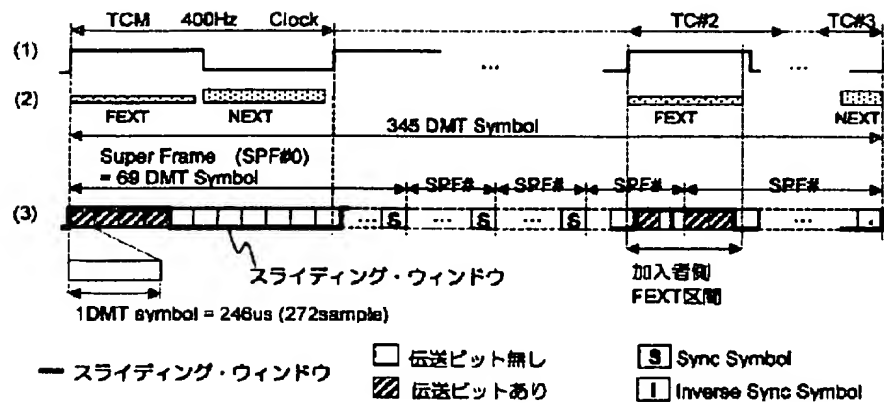
## ATU-C タイミング再生アルゴリズム

【图 1 1】



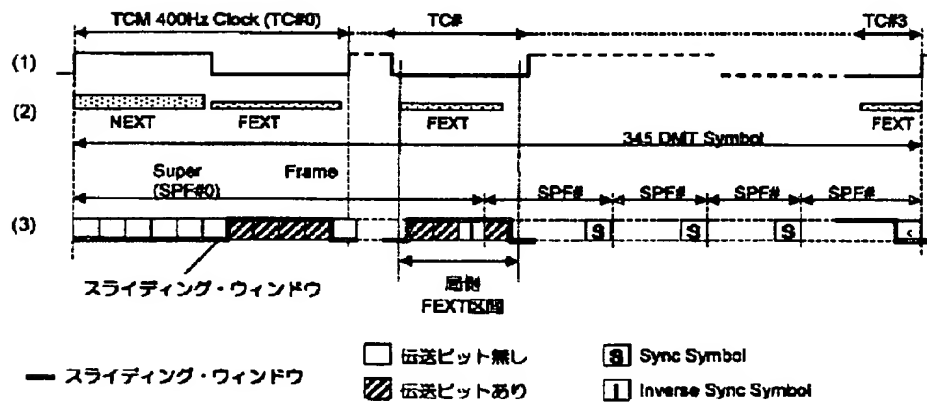
### ビットマップを2個使用する場合のSWB方式

【図 8】



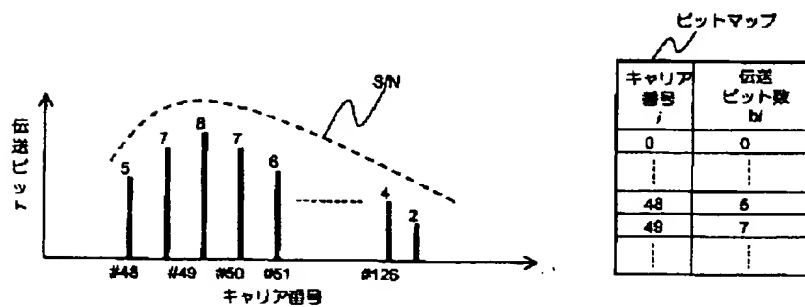
SWB方式の局側伝送パターン

【図 9】



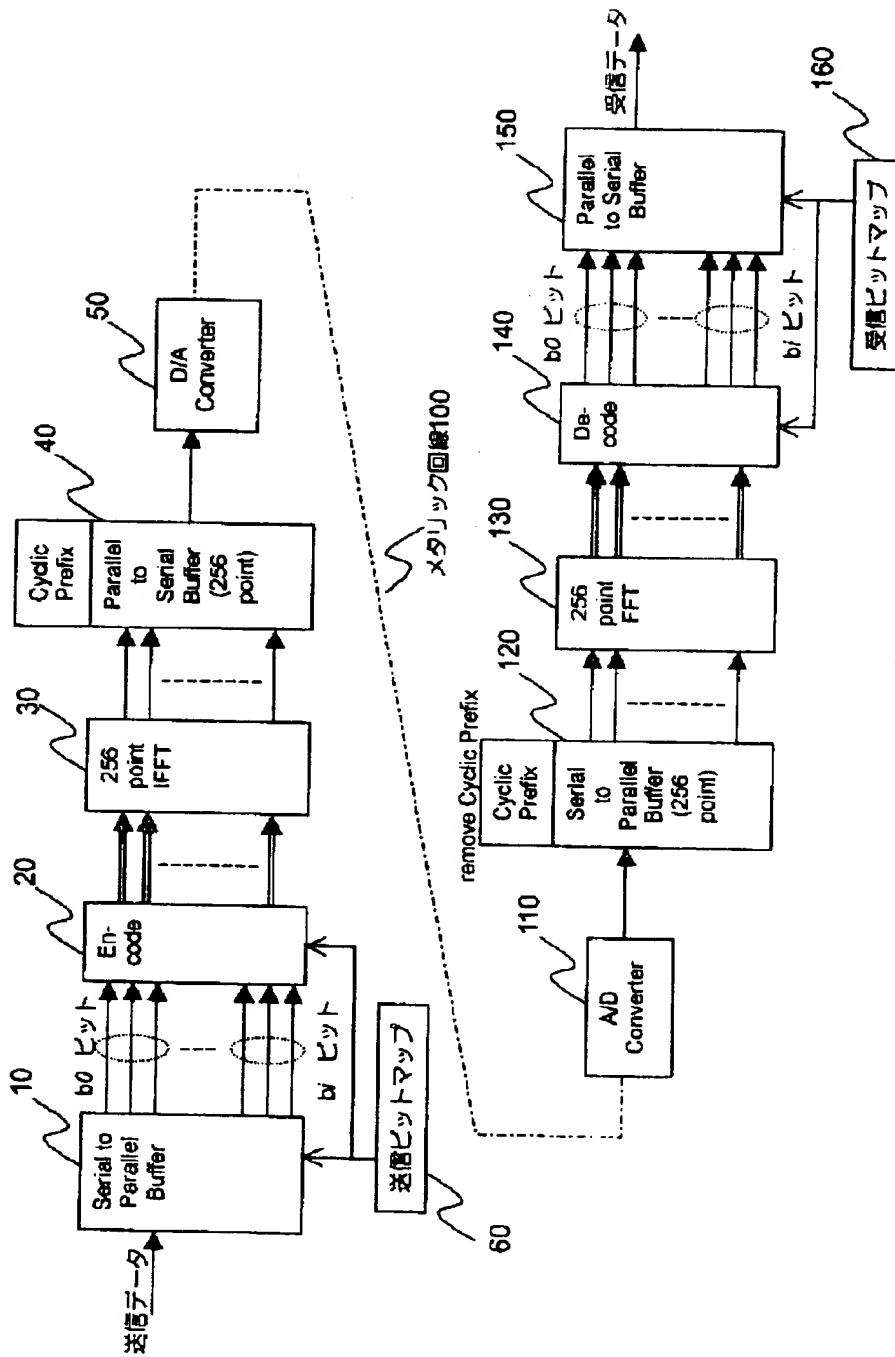
SWB方式の加入者側伝送パターン

【図 13】



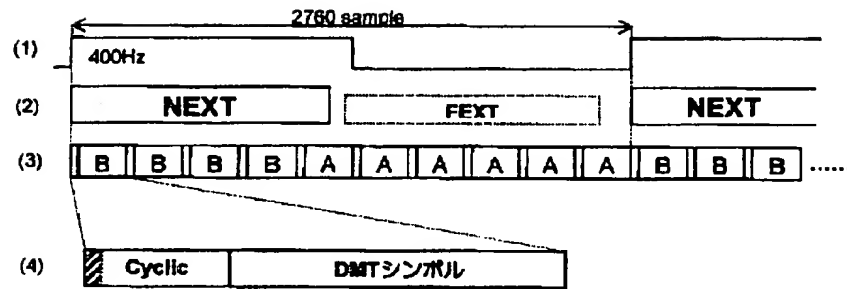
ビットマップの定義

【図12】



DMT変調方式による加入者伝送システムの機能ブロック

【図 14】



従来例

フロントページの続き

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**Description**

**BACKGROUND OF THE INVENTION**

**1. Field of the Invention**

[0001] The present invention relates to a digital subscriber line communicating system and a transceiver in the system which utilize an existing telephone line as a high speed data communication line. More particularly, it relates to an improvement of a modulation/demodulation system in a transmission apparatus used in the above-mentioned communication system.

[0002] In recent years, multimedia services such as internet and so forth have expanded through society and into homes. Accompanied by such development, it has been strongly required to promptly provide an economical and reliable digital subscriber line communicating system for utilizing such services.

**2. Description of the Related Art**

**(1) An explanation of an ADSL**

[0003] As a technique to provide a subscriber line communicating system which utilizes the existing telephone line as a high speed data communication line, an xDSL (Digital Subscriber Line) is known. xDSL is a communicating system which utilizes a telephone line and a modulation/demodulation technique. xDSLs are generally classified into a symmetric type and an asymmetric type. In the symmetric type, upstream transmission speed from a subscriber home (hereinafter referred to as a remote terminal side or an RT side) to an accommodating central office (hereinafter referred to as a central office side or a CO side) is symmetric with the transmission speed from the central office side to the remote terminal side. In the asymmetric type, the transmission speed from the remote terminal side to the central office side is asymmetric with the transmission speed from the central office side to the remote terminal side.

[0004] In the asymmetric xDSLs, there is an Asymmetric DSL (ADSL) modem which is provided with the G.DMT standard having a downstream transmission speed of about 6 Mbit/sec. and the G.lite standard having a downstream transmission speed of about 1.5 bits/sec. Both of the G.DMT and G.lite employ Discrete Multitone (DMT) modulation.

**(2) An Explanation of the DMT Modulation**

[0005] DMT modulation will be explained using G.lite as an example. This explanation and the associated drawing will describe only the downstream modulation/demodulation from the central office to the remote terminal. However, DMT modulation is also possible in the upstream modulation/demodulation.

[0006] Firstly, transmitting data is input into an ADSL transceiver unit (ATU) in the central office and a one-symbol time (1/4 kHz) of the data is stored in a serial to parallel buffer. The stored data are divided into a plurality of groups. A predetermined number of transmission bits per carrier signal is previously allocated to each group in accordance with a transmitting bitmap which will be described later in detail. Each group is output to an encoder. In the encoder, each group of the input bit series is converted into a signal point expressed by a complex number for an orthogonal amplitude modulation and is output to IFFT. The IFFT performs the conversion from each of the signal points to transmitting signal sequences by an inverse fast Fourier transform. The signals from the IFFT are output to a parallel to serial buffer. Here the sixteen points of the outputs of the IFFT are added as a Cyclic Prefix to the head of each DMT symbol. The output of the parallel to serial buffer is supplied to a D/A converter in which the digital signal with a sampling frequency of 1.104 MHz is converted into an analog signal. The analog signal is transmitted through a metallic line to a remote terminal.

[0007] At the remote terminal side, the analog signal is converted into a digital signal with the sampling frequency of 1.104 MHz by an A/D converter. Each DMT symbol of the digital signal is stored in a serial to parallel buffer. In the buffer, the Cyclic Prefix is removed from the digital signal, and the remaining signal is output to an FFT. In the FFT, a fast Fourier transform is effected to generate or demodulate the signal points. The demodulated signal points are decoded by a decoder in accordance with a receiving bitmap having the same values as those in the transmitting bitmap. The decoded data are stored in a parallel to serial buffer as receiving data of bit-sequences.

**(3) A Detailed Explanation of the Bitmap**

[0008] The bitmap described in the explanation of the DMT will be explained in detail with reference to Figs. 13A and 13B.

[0009] The apparatus at the central office side and the apparatus at the remote terminal side both measure the ratio of the receiving signal to noise (hereinafter referred to as S/N) during a training period prior to communication to deter-

mine the number of bits to be transmitted by each modulating carrier. As shown in Figs. 13A and 13B, for a carrier signal with a larger S/N, a larger number of bits to be transmitted are allocated; and for a carrier signal with a smaller S/N, a smaller number of bits to be transmitted are allocated.

[0010] By the above allocation, the receiving side measures the S/N to prepare the bitmap which indicates the numbers of bits to be transmitted corresponding to the carrier numbers.

[0011] The receiving side informs this bitmap to the transmitting side during a training period so that both the transmitting side and the receiving side can perform the modulation/demodulation with the use of the same bitmap during normal data communication.

#### 10 (4) Countermeasure Against Cross-Talk From the Time Compression Modulation ISDN Transmission (hereinafter referred to as TCM ISDN Transmission)

[0012] When there is a cross-talk due to the TCM ISDN Transmission, in the prior art, two different bitmaps are used in the ADSL modem in the transmitting side or in the receiving side so as to improve the transmission characteristic. This method of using the two bitmaps will be explained with reference to Fig. 14.

[0013] In the TCM ISDN transmission, the central office side transmits downstream data during a prior half of one cycle of a reference clock signal of 400 Hz shown in (1) of Fig. 14, in synchronization with the reference clock signal of 400 Hz; and the remote terminal side receives the downstream data and then transmits upstream data. Therefore, the ADSL modem in the central office is influenced by a Near End Cross-Talk (hereinafter referred to as NEXT) from the downstream ISDN during the prior half of the one cycle of 400 Hz, and is influenced by a Far End Cross-Talk (hereinafter referred to as FEXT) from the upstream ISDN during the latter half of one cycle of 400 Hz.

[0014] Contrary to the central office, the ADSL modem in the remote terminal is influenced by a FEXT during a prior half of one cycle of the reference clock signal of 400 Hz, and is influenced by a NEXT during a latter half of the cycle.

[0015] If the metallic cable between the central office and the remote terminal is long, the S/N of the receiving signal to the NEXT is made smaller, and in some cases, the NEXT may be greater than the receiving signal.

[0016] In these cases, since the influence of the FEXT is not so large, in the prior art, two bitmaps are provided. One is a bitmap (DMT symbol X) for receiving signals during the NEXT period at the remote terminal. The other is a bitmap (DMT symbol Y) for receiving signals during the FEXT period at the remote terminal. During the NEXT period, in the prior art, the number of bits to be transmitted is made small so as to improve the resistance of the signals against the S/N. During the FEXT period, in the prior art, the number of bits to be transmitted is made large so as to increase the transmission capacity.

[0017] On the other hand, the time interval of one DMT symbol is usually 246  $\mu$ s with a Cyclic Prefix of 16 points. Contrary to this, in the prior art, in order to synchronize the DMT symbols with the TCM Cross-talk period of 400 Hz, the time interval of one DMT symbol is made to be 250  $\mu$ s with a Cyclic Prefix of 20 points so that one period of the TCM Cross-talk is made to coincide with the time period of ten DMT symbols, whereby the synchronization with the TCM Cross-talk is established.

#### (5) FEXT and NEXT

[0018] Fig. 2 is a timing chart showing the cross-talk that the ADSL receives from the TCM-ISDN.

[0019] The TCM-ISDN transmission is carried out at a frequency of 400 Hz with the period of 2.5 ms as shown in (1) of Fig. 2. During the first half cycle of each period of the TCM-ISDN, the CO side transmits symbols as shown in (2) of Fig. 2 and during the latter half cycle of the period, the RT side transmits symbols as shown in (3) of Fig. 2. In the first half cycle of the period of TCM-ISDN, therefore, the center ADSL unit (ATU-C) is affected by the near end cross-talk (NEXT<sub>C</sub>) from the TCM-ISDN, and in the latter half cycle, the ATU-C is affected by the far end cross-talk (FEXT<sub>C</sub>) from the TCM-ISDN as shown in (5) of Fig. 2. On the other hand, the subscriber ADSL unit (ATU-R) is affected by the FEXT<sub>R</sub> from the TCM-ISDN during the first half cycle of the one TCM-ISDN period, and by the NEXT<sub>R</sub> from the TCM-ISDN during the latter half cycle thereof. In this specification, the time areas affected by NEXT and FEXT in this way will be called the NEXT duration and the FEXT duration, respectively as shown in (4) and (5) of Fig. 2.

[0020] The center ADSL unit (ATU-C) in the CO side can estimate or define the FEXT<sub>R</sub> duration and the NEXT<sub>R</sub> duration at the subscriber ADSL unit (ATU-R) in the RT side. Also, the ADSL unit (ATU-R) in the RT can estimate or define the FEXT<sub>C</sub> duration and the NEXT<sub>C</sub> duration at the center ADSL unit (ATU-C) in the CO. That is, each period is estimated or defined as follows.

FEXT<sub>R</sub>: FEXT duration at ATU-R estimated by ATU-C  
 NEXT<sub>R</sub>: NEXT duration at ATU-R estimated by ATU-C  
 FEXT<sub>C</sub>: FEXT duration at ATU-C estimated by ATU-R  
 NEXT<sub>C</sub>: NEXT duration at ATU-C estimated by ATU-R

The transmission delay is also taken into consideration in these definitions.

(6) Sliding Window

[0021] For the purpose of providing a digital subscriber line transmission system capable of transmitting the ADSL signal in satisfactory manner in the cross-talk environment from the TCM-ISDN described above, the present applicant has earlier proposed to introduce a "sliding window" in Japanese Patent Application No. 10-144913 (corresponding to U.S. Patent Application Serial No.: 09/318,445 filed on May 25, 1999) which is incorporated herein by reference.

[0022] According to Patent Application No. 10-144913, in the downstream transmission of the ADSL signal from the center ADSL unit (ATU-C) to the subscriber ADSL unit (ATU-R), the state of the ADSL signal transmitted by the center ADSL unit (ATU-C) in the cross-talk environment from the TCM-ISDN is defined as follows.

[0023] That is, in the case where the transmission symbol is completely contained in the FEXT<sub>R</sub> duration, as shown in Fig. 3, the center ADSL unit (ATU-C) transmits the symbol as an inside symbol by means of the sliding window. Also, in the case where the transmission symbol is included in the NEXT<sub>R</sub> duration even partially, the center ADSL unit (ATU-C) transmits the symbol as an outside symbol.

[0024] According to the dual bitmap mode, the center ADSL unit (ATU-C) transmits the inside symbol using a bitmap A for the FEXT<sub>R</sub> duration and the outside symbol using a bitmap B for the NEXT<sub>R</sub> duration.

[0025] Similar to in the downstream transmission, according to the dual bitmap mode the subscriber ADSL unit (ATU-R) transmits the inside symbol using the bitmap A for the FEXT<sub>C</sub> duration and transmits the outside symbol using the bitmap B for the NEXT<sub>C</sub> duration in the upstream transmission.

[0026] Here, there is a case where the center ADSL unit (ATU-C) does not use the bitmap B. This case is a single bitmap mode. In such a case, the center ADSL unit (ATU-C) transmits only the pilot tone outside of the sliding window. In similar fashion, there is case where the subscriber ADSL unit (ATU-R) does not use the bitmap B. This case is also the single bitmap mode. In the single bitmap mode, the subscriber ADSL unit (ATU-R) transmits nothing outside of the sliding window.

[0027] As described above, an effective transmission technique under the noise environment from the TCM-ISDN has been proposed, for example, in Japanese Patent Application No. 10-144913 by the present applicant. Nevertheless, a specific training method for the ADSL transceiver in employing such a transmission technique or means for carrying out the training method have yet to be studied.

SUMMARY OF THE INVENTION

[0028] The present invention has been developed based on new knowledge and study of the points described above, and the object thereof is to provide a digital subscriber line transmission system and a communication apparatus used for the transmission system accompanied by a specific training method for the ADSL transceiver in employing an effective transmission technique for the ADSL signal under the noise environment from the TCM-ISDN or including means for carrying out such a training method.

[0029] According to the present invention, there is provided a digital subscriber line communicating system for communicating through a communication line, including: means for generating a sliding window based on a timing signal representing a periodical noise duration; and means for discriminating, based on a status of the sliding window, which kind of durations of the periodical noise duration a transmitting data symbol belongs to.

[0030] The system may further includes means for performing an initial training of a receiver equalizer according to the status of the sliding window.

[0031] Specifically, according to a first aspect of the invention, there is provided a digital subscriber line communicating system for communicating between a transmitting side and a receiving side through a communication line, comprising a sliding window generating unit for generating a sliding window based on a timing signal representing a periodical noise duration, and a sliding window transmitting unit for transmitting modulated symbol according to the sliding window through the communication line to the receiving side.

[0032] The sliding window generating unit comprises a hyperframe counter for periodically counting a predetermined number of continuous transmitting modulated symbols constituting a hyperframe synchronized with the timing signal; and a decoder for discriminating, based on the count value output from the hyperframe counter, whether a transmitting data symbol belongs to a far end cross-talk duration at the receiving side or a near end cross-talk duration at the receiving side.

[0033] According to a second aspect of the present invention, the hyperframe counter is reset each time when the hyperframe counter counts the predetermined number of continuous transmitting data symbols.

[0034] According to a third aspect of the present invention, the transmitting side is a central office and the receiving side is a remote terminal.

[0035] In this case, the central office comprises: a timing signal generating unit for generating the timing signal syn-

chronized with a periodical noise including the periodical noise duration which interferes with the central office and the remote terminal; a receiver equalizer for example time domain equalizer and a frequency domain equalizer; and a sequencer for effecting a transition of the status of initialization of the central office during an initialization period before starting usual communication.

5 [0036] According to the fourth aspect of the present invention, the transmitting side is a remote terminal and the receiving side is a central office.

[0037] In this case, the remote terminal comprises: a timing signal generating unit for generating the timing signal synchronized with a periodical noise including the periodical noise duration which interferes the remote terminal and the central office; a receiver equalizer; and a sequencer for effecting a transition of the status of initialization of the remote terminal during an initialization period before starting usual communication.

10 [0038] In both the third and fourth aspects of the present invention, the initialization period includes an activation and acknowledgement sequence, a transceiver training sequence for performing an initial training of the receiver equalizer, a channel analysis sequence for measuring the quality of the communication line, and an exchange sequence for determining the transmitting capacity of the communication line based on the measured quality of the communication line.

15 [0039] In both the third and fourth aspects of the present invention, the sequencer effects the transition of the status based on the value counted by said hyperframe counter.

[0040] In both the third and fourth aspects of the present invention, during the transceiver training sequence, the exchange sequence, and the channel analysis sequence, the initialization is carried out by transmitting modulated symbols through only the inside of the sliding window.

20 [0041] In both the third and the fourth aspects of the present invention, during the transceiver training sequence, the exchange sequence, and the channel analysis sequence except for a quality measuring sequence, the initialization is carried out by transmitting modulated symbols through only inside of sliding window, and during the quality measuring sequence in the channel analysis sequence, the initialization is carried out by transmitting modulated symbols through both the inside and the outside of the sliding window.

25 [0042] In both the third and the fourth aspects of the present invention, the system further comprises a sequence transition determining unit for making a transition, in synchronization with the timing signal, from the activation and acknowledgement sequence to the transceiver training sequence or from the transceiver training sequence to the channel analysis sequence.

30 [0043] In both the third and the fourth aspects of the present invention, according to a dual bitmap mode, the modulated symbols are transmitted from the transmitting side through both the inside and the outside of the sliding window, and the modulated symbols are used for training of the receiver equalizer by the receiving side only when the receiving side is in a far end cross-talk duration.

[0044] In both the third and the fourth aspects of the present invention, according to the dual bitmap mode, during the training of the receiver equalizer in the transceiver training sequence, a step size for updating coefficients of the equalizer is made to be zero in the near end cross-talk duration, or to be a value smaller than the value in the far end cross-talk duration in the near end cross-talk duration at the receiving side, so that the transceiver training sequence is carried out continuously in the far end cross-talk duration and the near end cross-talk duration at the receiving side.

35 [0045] In both the third and fourth aspects of the present invention, the receiving side comprises; a synchronization symbol detecting unit for detecting a synchronization symbol included in each of superframes which constitute the hyperframe; an inverse synchronization symbol detecting unit for detecting an inverse synchronization symbol included in the hyperframe; and an inverting unit for rotating the phase of each carrier signal of the detected inverse synchronization symbol, except for the carrier signal of a pilot tone, by substantially 180° to obtain an inverted inverse synchronization symbol having the same phase as the phase of each of the detected synchronization symbols. In this case, the detected synchronization symbols and the inverted inverse synchronization symbol are used for the training of receiver equalizer.

40 [0046] According to a fifth aspect of the present invention, there is provided a digital subscriber line communicating system for communicating between a transceiver in a central office and a transceiver in a remote terminal through a communication line, wherein, during timing recover training sequence between the central office and the remote terminal, an inside symbol of a downstream sliding window is formed by a first kind of signal, and an outside symbol of the downstream sliding window is formed by a second kind of signal. In this case, the first kind of signal and the second kind of signal are obtained by modulating a carrier signal but are different in phase by a predetermined angle. The transceiver in the remote terminal recognizes whether a received symbol belongs to a far end cross-talk duration at the remote terminal or a near end cross-talk duration at the remote terminal, by detecting the phase of the output of a fast Fourier transform of the carrier signal, so as to recognize the phase of a timing signal which represents a periodical noise duration.

55 [0047] According to a sixth aspect of the present invention, a quadrature phase shift keying demodulation is employed to recognize the phase of a timing signal.

[0048] According to a seventh aspect of the present invention, there is provided a digital subscriber line communicat-

ing system for communicating between a central office and a remote terminal; the central office comprising; a phase-locked loop circuit for synchronizing a network timing reference signal, having a frequency higher than the frequency of a first timing signal, with an oscillating signal of a crystal oscillator provided in the central office, to generate a master clock signal; and a timing signal regenerating circuit for shifting the phase of the first timing signal to provide a synchronization in phase with the phase of the master clock signal so as to generate a second timing signal to be used in the central office.

[0049] According to an eighth aspect of the present invention, there is provided a transceiver to be connected through a communication line, having the same features as in the above-described system.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0050] The above objects and features of the present invention will be more apparent from the following description of the preferred embodiments with reference to the accompanying drawings, wherein:

- Fig. 1A is a block diagram showing a central office according to an embodiment of the present invention;
- Fig. 1B is a block diagram showing a remote terminal according to an embodiment of the present invention;
- Fig. 2 is a timing chart of the TCM-ISDN cross-talk;
- Fig. 3 is a diagram showing a sliding window;
- Figs. 4A and 4B are a diagram schematically showing timing charts for initialization;
- Fig. 5 is a block diagram showing a sliding window generating unit and a sequencer according to an embodiment of the invention;
- Fig. 6 is a diagram showing the QPSK demodulation;
- Fig. 7 is a block diagram showing a reference model of the ATU-C transmitter;
- Fig. 8 is a diagram showing a reference clock signal generating unit in the ATU-C;
- Fig. 9 is a diagram showing a transmission pattern of SWB method at the central office side;
- Fig. 10 is a pattern showing a transmission pattern of SWB method at the remote terminal side;
- Fig. 11 is a diagram showing a signal modulating point during timing recover sequence;
- Fig. 12 is a diagram showing the SWB method in the case where two bitmaps are used;
- Figs. 13A and 13B are diagrams showing the definition of a bitmap; and
- Fig. 14 is a diagram showing a conventional signal structure.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0051] An embodiment of the present invention will be described below with reference to the drawings.

[0052] Fig. 1A is a block diagram showing functional blocks of a central office according to an embodiment of the present invention; and Fig. 1B is a block diagram showing functional blocks of a remote terminal according to an embodiment of the present invention.

[0053] As shown in Fig. 1A, the central office includes a reference clock signal generating unit 1, a sliding window generating unit 2, a sequencer 3, and a sliding window transmitting unit 4. The reference signal generating unit 1 generates a reference clock signal having a frequency of, for example, 400 Hz, synchronized with a TCM ISDN transmission which interferes with the central office and the remote terminal. The reference clock signal may be generated based on an external signal or with an internal signal generated by a crystal oscillator as an example.

[0054] The sliding window generating unit 2 generates a downstream sliding window from the generated reference clock signal. The downstream sliding window discriminates whether the transmitting DMT symbols are received in a far end cross-talk duration or in the other duration at the remote terminal. The discriminated result is sent to the sliding window transmitting unit 4.

[0055] The sequencer 3 controls a sequence transition in the central office during an initialization period of the communicating system.

[0056] The sliding window transmitting unit 4 transmits the DMT symbols according to the downstream sliding window to the remote terminal.

[0057] As shown in Fig. 1B, the remote terminal includes a sliding window receiving unit 5, a reference clock signal generating unit 6, a sliding window generating unit 7, and a sequencer 8.

[0058] The sliding window receiving unit 5 receives the DMT symbol, according to the downstream sliding window from the central office,

[0059] The reference clock signal generating unit 6 generates a reference clock signal from received DMT symbols which are transmitted from the central office according to the sliding window.

[0060] The sliding window generating unit 7 generates a downstream sliding window from the generated reference clock signal by the reference clock signal generating unit 6. The generated downstream sliding window defines whether

the received DMT symbols are received in a far end cross-talk duration or other duration at the remote terminal.

[0061] The sequencer 8 controls a sequence transition in the remote terminal during the initialization period of the communicating system.

[0062] The reference clock signal in the central office may be generally referred to as a timing signal which is synchronized with the transmission system which interferes with the central office and the remote terminal.

[0063] DMT modulation will be explained using the G.lite as an example and with reference to Figs. 1A and 1B. This explanation and the associated drawings will describe only the downstream modulation/demodulation from the central office to the remote terminal. However, the DMT modulation is also possible in the upstream direction.

[0064] Firstly, transmitting data is input into an ADSL transceiver unit (ATU) in the central office and a one-symbol time (1/4 kHz) of the data is stored in a serial to parallel buffer 10. The stored data are divided into a plurality of groups. A predetermined number of transmission bits  $b_0, \dots, b_i$  per a carrier signal is previously allocated to each group in accordance with a transmitting bitmap 60 which will be described later in detail. Each group is output to an encoder 20. In the encoder 20, each group of the input bit series is converted into a signal point expressed by a complex number for an orthogonal amplitude modulation and is output to IFFT 30. The IFFT 30 performs the conversion from each of the signal points to transmitting signal sequence by an inverse fast Fourier transform. The signals from the IFFT 30 are output to a parallel to serial buffer 40. Here the sixteen tail points 240 - 255 of the outputs of the IFFT 30 are added as a Cyclic Prefix to the head of each DMT symbol. The output of the parallel to serial buffer 40 is supplied to a D/A converter 50 in which the digital signal with a sampling frequency of 1.104 MHz is converted into an analog signal. The analog signal is transmitted through a metallic line 100 to a remote terminal.

[0065] At the remote terminal side, the analog signal is converted into a digital signal with a sampling frequency of 1.104 MHz by an A/D converter 110. Each DMT symbol of the digital signal is stored in a serial to parallel buffer 120. In the buffer 120, the Cyclic Prefix is removed from the digital signal, and the remaining signal is output to an FFT 130. In the FFT 130, a fast Fourier transform is effected to generate or demodulate the signal points. The demodulated signal points are decoded by a decoder 140 in accordance with a receiving bitmap 160 having the same values as those in the transmitting bitmap 60. The decoded data are stored in a parallel to serial buffer 150 as receiving data of bit-sequences  $b_0, \dots, b_i$ .

[0066] In the following, an initialization, a sliding window generating unit and a sequencer, a transceiver training, and an inverse synchronization symbol will be described.

#### (1) Initialization

[0067] Figs. 4A and 4B schematically show timing charts for the initialization of the ADSL transceivers ATU-C and ATU-R. The initialization period includes an activation and acknowledgement sequence for determining whether a dual bitmap mode or a single bitmap mode should be used in the central office or in the remote terminal, a transceiver training sequence for performing an initial training of the central office or the remote terminal, a channel analysis sequence for measuring the quality of said communication line, and an exchange sequence for determining the transmitting capacity of the communication line based on the measured quality of said communication lines, and for informing the transmitting capacity to each other. The channel analysis sequence includes a C-MEDLEY in the ATU-C and an R-MEDLEY in the ATU-R. The C-MEDLEY and the R-MEDLEY are sequences for measuring S/N. At the time of ADSL training, it is important to send out ADSL signals only during the period when the NEXT noise for the TCM-ISDN is not generated at the TCM-ISDN receiving side, taking the effect on the TCM-ISDN into account for both upstream and downstream transmission. For this reason, as shown in Figs. 4A and 4B, during the transceiver training and exchange sequence, the initialization is performed according to the single bitmap mode. Also, during the channel analysis sequence, the initialization is performed according to the single bitmap mode for the sequences other than the C-MEDLEY and the R-MEDLEY. During the C-MEDLEY and the R-MEDLEY, on the other hand, the line quality is checked, that is, S/N is measured by both the inside and outside symbols according to a dual bitmap mode, or by the inside symbol only according to a single bitmap mode.

#### (2) Sliding window Generating Unit and Sequencer

[0068] Fig. 5 shows the construction of the sliding window generating unit 2 or 7 in Fig. 1A or 1B, and the construction of the sequencer 3 or 8 in Fig. 1A or 1B, according to an embodiment of the present invention.

[0069] The sliding window generating unit and sequencer shown in Fig. 5 is included in each of the center ADSL unit (ATU-C) and the subscriber ADSL unit.

[0070] As shown in Fig. 5, the sliding window generating unit includes a hyperframe counter 501, a sliding window decoder 503, and the sequencer includes a symbol number counter 505, a transition condition logic unit 507, a comparator 509, a sequence counter 511, a count value decoder 513, and an initialization decoder 515. The timing signal (400Hz) 517 is provided from the reference clock generating unit 1 or 6 in Fig. 1A or 1B. The DMT symbol clock 519

has a period of one DMT symbol time. The sequence transition information 521 is an external condition for sequence transition (for example, activation signal detection flag, etc.). The FEXT/NEXT signal 523 represents inside or outside of the sliding window. The initialization information signal control the transmitting unit and receiving unit according to initialization sequence.

5 [0071] In operation, the hyperframe counter 501 counts the number of DMT symbols by counting the DMT symbol clocks 519 a predetermined number of times (for example, 345 times) continuously. Using this count value, the sliding window decoder 503 discriminates whether a transmitting or receiving DMT symbol belongs to a FEXT<sub>R</sub>, NEXT<sub>R</sub>, FEXT<sub>C</sub> or NEXT<sub>C</sub> duration in the sliding window.

10 [0072] Also, the center ADSL unit ATU-C starts the C-REVEILLE (the first sequence of downstream transceiver training sequence) and C-RATES1 (the first sequence of downstream channel analysis sequence), and the subscriber ADSL unit ATU-R starts the R-REVERB3 (the first sequence of upstream channel analysis sequence), respectively, synchronized in phase with the timing signal 517 having a frequency of 400 Hz. This can be realized by making the 400 Hz timing signal 517 as the condition for sequence transfer in the transition condition logic unit 507 and by clearing the hyperframe counter 501 in response to the timing signal. The symbol number counter 505 counts the number of DMT symbols by counting the DMT symbol clocks 519, and by making the comparison with the number of the DMT symbols output from the count decoder 513 as a condition for sequence transfer in the transition condition logic unit 507, the number of DMT symbols is the length of each sequence in the initialization period. Also, the sequence transition information 521 is input as a sequence transition condition into the transition condition logic unit 507. When the sequence transition occurs, the transition condition logic unit 507 outputs an enable signal to the enable terminal EN of the sequence counter 511. Thus, the sequence counter 511 increments its count each time when the sequence in the initialization period transfers from one sequence to the next sequence. The count value decoder 513 decodes the count value output from the sequence counter 511 to output the number of the DMT symbols corresponding to the count value, i.e., the length of the sequence. The count value output from the sequence counter 511 is also input to the initialization decoder 515. The initialization decoder 515 generates an initialization information 525 to control the transmitting unit and receiving unit, for example, determining the initialization signals such as the C-REVEILLE and the C-PILOT1 (timing recovery training signals in transceiver training sequence), etc. to be transmitted or to be received.

25 [0073] The above-described configuration has been described as realized with hardware, however, it can also be realized in software with a similar configuration.

30 [0074] Also, in the C-PILOT1, the phase of the TCM-ISDN timing signal of 400 Hz is notified from the center ADSL unit (ATU-C) to the subscriber ADSL unit (ATU-R), which in turn detects and converts it into a timing signal having a frequency of 400 Hz by the reference clock signal generating unit 6 in Fig. 1B. In this method, though described in detail later, the subscriber ADSL unit (ATU-R) can periodically detect cross-talk duration of TCM-ISDN.

### (3) Transceiver Training Sequence

35 [0075] The transceiver training sequence includes a timing recovery training sequence, an automatic gain control AGC training sequence, equalizer training sequence such as a time domain equalizer TEQ, a frequency domain equalizer FEQ, and a training sequence for frame synchronization. These trainings are performed when a pseudo random signal such as a synchronization symbol S is repeatedly sent out by the ADSL transceiver. In the transceiver training sequence, the initialization is performed according to a single bitmap mode in which synchronization symbols are transmitted and received only in the FEXT<sub>R</sub> or FEXT<sub>C</sub> duration, so that the transceiver training sequence is performed only in the FEXT<sub>R</sub> or FEXT<sub>C</sub> duration as a matter of course.

40 [0076] It should be noted that there may be a case in which, in the initialization in the transceiver training sequence, even when training symbols are transmitted according to a dual bitmap mode in which the training symbols are transmitted in both inside and outside of the sliding window, the receiving side may use the training symbols only inside of the sliding window for training the equalizer.

45 [0077] In the equalizer training sequence in the transceiver training sequence, a step size for updating coefficients of the equalizer such as TEQ and FEQ in the NEXT<sub>R</sub> or NEXT<sub>C</sub> duration is made to be zero or to be a very small value smaller than the value in the FEXT<sub>R</sub> or FEXT<sub>C</sub> duration, so that the equalizer training sequence is carried out continuously whether the training symbol is transmitted both inside and outside of the sliding window.

### (4) Inverse synchronization symbol

50 [0078] As shown in Figs. 9 and 10, each hyperframe contains one inverse synchronization symbol I. In each equalizer training, however, the inverse synchronization symbol I is also used in combination with the synchronization symbol S in the following manner in order to improve the convergence rate.

[0079] Upon receipt of the inverse synchronization symbol I at the receiving side, the phase of each carrier except for the pilot tone is rotated by an inverter 135 by 180 degrees after the fast Fourier transform by the FET 130 shown in Fig.

1B. AS a result, the same state as realized as when the synchronization symbol S is received. Then, the training is carried out using the synchronization symbol S generated at the receiving side.

[0080] For watching or re-synchronizing the superframe or the hyperframe synchronization, in the case where the synchronization symbol S is detected, the detection is checked with the next inverse synchronization symbol I, and in the case where the inverse synchronization symbol I is detected, on the other hand, the detection is checked with the next detected synchronization symbol S.

(5) Method of Informing the Phase of TCM-ISDN Timing Signal With 400 Hz From Center ADSL Unit (ATU-C) to Subscriber ADSL unit (ATU-R)

[0081] A method for informing the phase of TCM-ISDN timing signal with 400 Hz from the center ADSL unit (ATU-C) to the subscriber ADSL unit (ATU-R) is described in detail below.

[0082] In addition to the pilot tone, the C-PILOT1 transmits an i-th carrier belonging to the frequency band with small cross-talk from TCM-ISDN. The i-th carrier may be, for example, 74th carrier having a frequency of 319.125 kHz. The phase of TCM-ISDN timing signal with 400 Hz is informed from the center ADSL unit (ATU-C) to the subscriber ADSL unit (ATU-R) in the i-th carrier using 4-quadrature amplitude modulation (QAM) in the manner described below. This informing process is shown in Fig. 11 and table 1 below.

[Table 1]

DURATION	BIT SEQUENCE BEFORE MODULATION	PHASE AFTER MODU- LATION
FEXT <sub>R</sub> DURATION (BITMAP A)	{0, 0}	(++)
NEXT <sub>R</sub> DURATION (BITMAP B)	{0, 1}	(+-)

[0083] As can be seen from Fig. 11 and the table 1, the two bits {0, 0} in the FEXT<sub>R</sub> duration are modulated to (++) which represents the first quadrant; and the two bits {0, 1} in the NEXT<sub>R</sub> duration are modulated to (+-) which represents the fourth quadrant.

[0084] The subscriber ADSL unit (ATU-R) receives the i-th carrier sent thereto from the center ADSL unit (ATU-C) and recognizes the phase of the TCM-ISDN timing signal with 400 Hz by either of the two methods described below.

(i) Method of Recognizing the Phase of the TCM-ISDN Timing Signal With 400 Hz by Performing a Fast Fourier Transform

[0085] The subscriber ADSL unit (ATU-R), after receiving the i-th carrier, executes the fast Fourier transform by the FFT 130 shown in Fig. 1B. From the phase of this FFT output, it recognizes whether the carrier belongs to the FEXT<sub>R</sub> duration or the NEXT<sub>R</sub> duration. The subscriber ADSL unit recognizes the phase of the TCM-ISDN timing signal of 400 Hz using this information.

[0086] In this method, however, the subscriber ADSL unit (ATU-R) can recognize the phase of the TCM-ISDN timing signal of 400 Hz only with a relatively low accuracy. The following method is effective for achieving a higher accuracy.

(ii) Method of Recognizing the Phase of the TCM-ISDN Timing Signal with 400 Hz by Carrying Out QPSK Demodulation

[0087] The subscriber ADSL unit (ATU-R) executes the QPSK demodulation as shown in Fig. 6 after receiving the i-th carrier. From this result, it recognizes that the receiving signal belongs to the FEXT<sub>R</sub> duration or the NEXT<sub>R</sub> duration. Using this information, the subscriber ADSL unit (ATU-R) recognizes the phase of the TCM-ISDN timing signal with 400 Hz.

[0088] This method makes it possible for the subscriber ADSL unit (ATU-R) to recognize the phase of the TCM-ISDN timing signal with 400 Hz with a high accuracy.

(6) Method of Configuring PLL of TCM-ISDN 400 Hz Burst Clock

[0089] Fig. 7 shows a reference model of the ATU-C transmitter. As shown in Fig. 7, the center ADSL unit (ATU-C) is kept supplied with a signal of 8 kHz clock called NTR (network timing reference) from an external source. The signal of the TCM-ISDN timing signal with 400 Hz may also be supplied from an external source. The TCM-ISDN timing signal

with 400 Hz may alternatively be generated in the center ADSL unit (ATU-C) without being supplied from an external source (see Japanese Patent Application No. 10-115223, for example). In this process, the TCM-ISDN timing signal with 400 Hz and the 8 kHz NTR are synchronized in frequency with each other.

[0090] Fig. 8 shows a reference clock signal generating unit in the ATU-C, according to a further embodiment of the present invention.

[0091] In Fig. 8, the NTR signal having a frequency of 8 kHz is applied to an analog PLL circuit 703. An oscillating signal of 17.664 MHz is generated from a crystal oscillator 704. By the analog PLL circuit 703, the oscillating signal from the crystal oscillator 704 is synchronized in phase with the NTR signal, so that the analog PLL circuit 703 outputs a master clock signal of 17.664 MHz. The frequency of the master clock signal is divided by a frequency divider 705 so that a sampling clock signal 708 with 1.104 MHz for A/D converters or D/A converters is obtained. The master clock signal is also applied to a timing signal regenerating circuit 707 in which the phase of the TCM-ISDN timing signal 702 is shifted to make a synchronization in phase with the phase of the master clock signal. Thus, the internal timing signal 709 having the frequency of 400 Hz is obtained.

[0092] In the preceding art, the TCM-ISDN timing signal 702 of 400 Hz is input to the analog PLL circuit 703 in the center ADSL unit (ATU-C), and is synchronized with the oscillating signal from the VCXO 704 therein. The oscillation frequency of the VCXO of the, center ADSL unit (ATU-C) is 17.664 MHz for example. In such a case, in order to synchronize the signal from the VCXO 704 with the TCM-ISDN timing signal of 400 Hz, the phase comparison information is acquired once for each 44160 times ( $17.664 \text{ M}/400$ ) for PLL sync operation. Normally, the more the number of phase comparisons, the smaller the phase jitter or the frequency error. The phase comparison conducted once for each 44160 times with the clock of 17.664 MHz, however, normally increases the phase jitter and the frequency error greatly.

[0093] In order to avoid this, according to this embodiment, the NTR signal 701 with 8 kHz synchronized with the TCM-ISDN timing signal of 400 Hz which is always supplied to the center ADSL unit (ATU-C) from an external source is used to perform the PLL synchronization operation of VCXO in the center ADSL unit (ATU-C). Thus, the number of times of the phase comparison increases 20 times as large as for the TCM-ISDN timing signal with 400 Hz. Thus, the phase comparison information is obtained at the rate of once for each 2208 times, thereby making it possible to reduce the phase jitter and the frequency error.

[0094] The embodiments of the invention described above represent only an example, and other many modifications are conceivable. In any way, however, the present invention has, of course, the same effect.

[0095] It will thus be understood from the foregoing detailed description that according to this invention, there are provided a specific training method for the ADSL transceiver in employing an effective transmission technique for the ADSL signal in the noise environment from the TCM-ISDN or a digital subscriber line transmission system and a communication apparatus comprising means for carrying out the particular training method.

## Claims

1. A digital subscriber line communicating system for communicating between a transmitting side and a receiving side through a communication line, comprising:

a sliding window generating unit for generating a sliding window based on a timing signal representing a periodical noise duration; and

a sliding window transmitting unit for transmitting modulated symbol according to said sliding window through said communication line to said receiving side;

said sliding window generating unit comprising:

a hyperframe counter for periodically counting a predetermined number of continuous transmitting modulated symbols constituting a hyperframe synchronized with said timing signal; and

a decoder for discriminating, based on the count value output from said hyperframe counter, whether a transmitting data symbol belongs to a far end cross-talk duration at said receiving side or a near end cross-talk duration at said receiving side.

2. The digital subscriber line communicating system according to claim 1, wherein said hyperframe counter is reset each time when said hyperframe counter counts said predetermined number of continuous transmitting data symbols.

3. The digital subscriber line communicating system according to claim 1, wherein said transmitting side is a central office and said receiving side is a remote terminal;

said central office comprising:

a timing signal generating unit for generating said timing signal synchronized with a periodical noise including

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said periodical noise duration which interferes with said central office and said remote terminal;

a receiver equalizer; and

a sequencer for effecting a transition of the status of initialization of said central office during an initialization period before starting usual communication, said initialization period including an activation and acknowledgement sequence, a transceiver training sequence for performing an initial training of said receiver equalizer, a channel analysis sequence for measuring the quality of said communication line, and an exchange sequence for determining the transmitting capacity of said communication line based on the measured quality of said communication line.

4. The digital subscriber line communicating system according to claim 3, wherein, said sequencer effects the transition of the status based on the value counted by said hyperframe counter.

5. The digital subscriber line communicating system according to claim 3, wherein, during said transceiver training sequence, said exchange sequence, and said channel analysis sequence, said initialization is carried out by transmitting modulated symbols through only the inside of said sliding window.

6. The digital subscriber line communicating system according to claim 3, wherein, during said transceiver training sequence said exchange sequence, and said channel analysis sequence except for a quality measuring sequence, said initialization is carried out by transmitting modulated symbols through only the inside of said sliding window, and during said quality measuring sequence in said channel analysis sequence, said initialization is carried out by transmitting modulated symbols through both the inside and the outside of said sliding window.

7. The digital subscriber line communicating system according to claim 3, further comprising:

a sequence transition determining unit for making a transition, in synchronization with said timing signal, from said activation and acknowledge sequence to said transceiver training sequence or from said transceiver training sequence to said channel analysis sequence.

8. The digital subscriber line communicating system according to claim 1, wherein said transmitting side is a remote terminal and said receiving side is a central office;

said remote terminal comprising:

a timing signal generating unit for generating said timing signal synchronized with a periodical noise including said periodical noise duration which interferes with said remote terminal and said central office;

a receiver equalizer; and

a sequencer for effecting a transition of the status of initialization of the status of said remote terminal during an initialization period before starting usual communication, said initialization period including an activation and acknowledgement sequence, a transceiver training sequence for performing an initial training of said receiver equalizer, a channel analysis sequence for measuring the quality of said communication line, and an exchange sequence for determining the transmitting capacity of said communication line based on the measured quality of said communication line.

9. The digital subscriber line communicating system according to claim 8, said sequencer effects the transition of the status based on the value counted by said hyperframe counter.

10. The digital subscriber line communicating system according to claim 8, wherein, according to a single bitmap mode, during said transceiver training sequence, said exchange sequence, and said channel analysis sequence, said initialization is carried out by transmitting modulated symbols through only the inside of said sliding window.

11. The digital subscriber line communicating system according to claim 8, wherein, according to a dual bitmap mode, during said transceiver training sequence, said exchange sequence, and said channel analysis sequence except for a quality measuring sequence, said initialization is carried out by transmitting modulated symbols through only the inside of sliding window, and during said quality measuring sequence in said channel analysis sequence, said initialization is carried out by transmitting modulated symbols through both the inside and the outside of sliding window.

12. The digital subscriber line communicating system according to claim 8, further comprising:

a sequence transition determining unit for making a transition, in synchronization with said timing signal, from said activation and acknowledgement sequence to said transceiver training sequence or from said transceiver training sequence to said channel analysis sequence.

- 5 13. The digital subscriber line communicating system according to claim 3 or 8, wherein, according to a dual bitmap mode, said modulated symbols are transmitted from said transmitting side through both the inside and the outside of said sliding window, and said modulated symbols are used for training of said receiver equalizer by said receiving side only when said receiving side is in a far end cross-talk duration.
- 10 14. The digital subscriber line communicating system according to claim 3 or 8, wherein, according to said dual bitmap mode, during the training of said receiver equalizer in said transceiver training sequence, a step size for updating coefficients of said receiver equalizer is made to be zero in said near end cross-talk duration, or to be a value smaller than the value in said far end cross-talk duration in said near end cross-talk duration at said receiving side, so that said transceiver training sequence is carried out continuously in said far end cross-talk duration and said  
15 near end cross-talk duration at said receiving side.
15. The digital subscriber line communicating system according to claim 3 or 8, wherein said receiving side comprises:  
  
20 a synchronization symbol detecting unit for detecting a synchronization symbol included in each of super-frames which constitute said hyperframe;  
an inverse synchronization symbol detecting unit for detecting an inverse synchronization symbol included in said hyperframe; and  
an inverting unit for rotating the phase of each carrier signal of the detected inverse synchronization symbol, except for the carrier signal of a pilot tone, by substantially 180° to obtain an inverted inverse synchronization  
25 symbol having the same phase as the phase of each of the detected synchronization symbols;  
the detected synchronization symbols and the inverted inverse synchronization symbol being used for the training of said receiver equalizers
- 30 16. The digital subscriber line communicating system according to claim 3 or 8, wherein for watching or re-synchronizing the superframe or the hyperframe synchronization, in the case where the synchronization symbol is detected at the receiving side, the synchronization is checked with detection of the next inverse synchronization symbol, and in the case where the inverse synchronization symbol is detected, on the other hand, the synchronization is checked with the next detected synchronization symbol.
- 35 17. A digital subscriber line communicating system for communicating between a transceiver in a central office and a transceiver in a remote terminal through a communication line, wherein, during timing recover training sequence between said central office and said remote terminal, an inside symbol of a downstream sliding window is formed by a first kind of signal, and an outside symbol of said downstream sliding window is formed by a second kind of signal, said first kind of signal and said second kind of signal being obtained by modulating a carrier signal but  
40 being different in phase by a predetermined angle, and  
  
said transceiver in said remote terminal recognizes whether a received symbol belongs to a far end cross-talk duration at said remote terminal or a near end cross-talk duration at said remote terminal, by detecting the phase of the output of a fast Fourier transform of said carrier signal, so as to recognize the phase of a timing  
45 signal which represents a periodical noise duration.
- 50 18. A digital subscriber line communicating system for communicating between a transceiver in a central office and a transceiver in a remote terminal through a communication line, wherein, during timing recover training sequence between said central office and said remote terminal, an inside symbol of a downstream sliding window is formed by a first kind of signal, and an outside symbol of said downstream sliding window is formed by a second kind of signal, said first kind of signal and said second kind of signal being obtained by modulating a carrier signal but being different in phase by a predetermined angle, and  
  
55 said transceiver in said remote terminal recognizes whether a received symbol belongs to a far end cross-talk duration at said remote terminal or a near end cross-talk duration at said remote terminal, by detecting the phase of the output of a quadrature phase shift keying demodulation of said carrier signal, so as to recognize the phase of a timing signal which represents a periodical noise duration.

19. A digital subscriber line communicating system for communicating between a central office and a remote terminal;

said central office comprising;

a phase-locked loop circuit for synchronizing a network timing reference signal, having a frequency higher than the frequency of a first timing signal, with an oscillating signal of a crystal oscillator provided in said central office, to generate a master clock signal; and  
a timing signal regenerating circuit for shifting the phase of said first timing signal to provide a synchronization in phase with the phase of said master clock signal so as to generate a second timing signal to be used in said central office.

20. A transceiver to be connected through a communication line, comprising:

a sliding window generating unit for generating a sliding window based on a timing signal representing a periodical noise duration; and  
a sliding window transmitting unit for transmitting modulated symbol according to said sliding window through said communication line to said receiving side;  
said sliding window generating unit comprising:  
a hyperframe counter for periodically counting a predetermined number of continuous transmitting modulated symbols constituting a hyperframe synchronized with said timing signal; and  
a decoder for discriminating, based on the count value output from said hyperframe counter, whether a transmitting data symbol belongs to a far end cross-talk duration at said receiving side or a near end cross-talk duration at said receiving side.

21. The transceiver according to claim 20, wherein said hyperframe counter is reset each time when said hyperframe counter counts said predetermined number of continuous transmitting data symbols.

22. The transceiver according to claim 20, further comprising:

a timing signal generating unit for generating said timing signal synchronized with a periodical noise including said periodical noise duration which interferes with said transmitting data symbol;  
a receiver equalizer; and  
a sequencer for effecting a transition of the status of initialization of said transceiver during an initialization period before starting usual communication, said initialization period including an activation and acknowledgement sequence, a transceiver training sequence for performing an initial training of said receiver equalizer, a channel analysis sequence for measuring the quality of said communication line, and an exchange sequence for determining the transmitting capacity of said communication line based on the measured quality of said communication line.

23. The transceiver according to claim 22, wherein, said sequencer effects the transition of the status based on the value counted by said hyperframe counter.

24. The transceiver according to claim 22, wherein, during said transceiver training sequence, said exchange sequence, and said channel analysis sequence, said initialization is carried out by transmitting modulated symbols through only the inside of said sliding window.

25. The transceiver according to claim 22, wherein, during said transceiver training sequence said exchange sequence, and said channel analysis sequence except for a quality measuring sequence, said initialization is carried out by transmitting modulated symbols through only the inside of said sliding window, and during said quality measuring sequence in said channel analysis sequence, said initialization is carried out by transmitting modulated symbols through both the inside and the outside of said sliding window.

26. The transceiver according to claim 22, further comprising:

a sequence transition determining unit for making a transition, in synchronization with said timing signal, from said activation and acknowledge sequence to said transceiver training sequence or from said transceiver training sequence to said channel analysis sequence.

27. The transceiver according to claim 22, wherein, said modulated symbols are transmitted from said transmitting side

through both the inside and the outside of said sliding window, and said modulated symbols are used for training of said receiver equalizer by said receiving side only when said receiving side is in a far end cross-talk duration.

28. The transceiver according to claim 22, wherein, during the training of said receiver equalizer in said transceiver training sequence, a step size for updating coefficients of said receiver equalizer is made to be zero in said near end cross-talk duration, or to be a value smaller than the value in said far end cross-talk duration in said near end cross-talk duration at said receiving side, so that said transceiver training sequence is carried out continuously in said far end cross-talk duration and said near end cross-talk duration at said receiving side.

29. The transceiver according to claim 22, wherein said receiving side comprises:

a synchronization symbol detecting unit for detecting a synchronization symbol included in each of superframes which constitute said hyperframe;  
an inverse synchronization symbol detecting unit for detecting an inverse synchronization symbol included in said hyperframe; and  
an inverting unit for rotating the phase of each carrier signal of the detected inverse synchronization symbol, except for the carrier signal of a pilot tone, by substantially 180° to obtain an inverted inverse synchronization symbol having the same phase as the phase of each of the detected synchronization symbols;  
the detected synchronization symbols and the inverted inverse synchronization symbol being used for the training of said receiver equalizer.

30. The transceiver according to claim 22, wherein for watching or re-synchronizing the superframe or the hyperframe synchronization, in the case where the synchronization symbol is detected at the receiving side, the synchronization is checked with detection of the next inverse synchronization symbol, and in the case where the inverse synchronization symbol is detected, on the other hand, the synchronization is checked with the next detected synchronization symbol.

31. A transceiver to be connected through a communication line, wherein, during timing recover training sequence between said central office and said remote terminal, an inside symbol of a downstream sliding window is formed by a first kind of signal, and an outside symbol of said downstream sliding window is formed by a second kind of signal, said first kind of signal and said second kind of signal being obtained by modulating a carrier signal but being different in phase by a predetermined angle, and

said transceiver in said remote terminal recognizes whether a received symbol belongs to a far end cross-talk duration at said remote terminal or a near end cross-talk duration at said remote terminal, by detecting the phase of the output of a fast Fourier transform of said carrier signal, so as to recognize the phase of a timing signal which represents a periodical noise duration.

32. A transceiver to be connected through a communication line, wherein, during timing recover training sequence between said central office and said remote terminal, an inside symbol of a downstream sliding window is formed by a first kind of signal, and an outside symbol of said downstream sliding window is formed by a second kind of signal, said first kind of signal and said second kind of signal being obtained by modulating a carrier signal but being different in phase by a predetermined angle, and

said transceiver in said remote terminal recognizes whether a received symbol belongs to a far end cross-talk duration at said remote terminal or a near end cross-talk duration at said remote terminal, by detecting the phase of the output of a quadrature phase shift keying demodulation of said carrier signal, so as to recognize the phase of a timing signal which represents a periodical noise duration.

33. A transceiver in a central office connected through a communication line to a remote terminal, said transceiver comprising;

a phase-locked loop circuit for synchronizing a network timing reference signal, having a frequency higher than the frequency of a first timing signal, with an oscillating signal of a crystal oscillator provided in said central office, to generate a master clock signal; and  
a timing signal regenerating circuit for shifting the phase of said first timing signal to provide a synchronization in phase with the phase of said master clock signal so as to generate a second timing signal to be used in said central office.

34. A digital subscriber line communicating system for communicating through a communication line, including:

5 means for generating a sliding window based on a timing signal representing a periodical noise duration; and  
means for discriminating, based on a status of said sliding window, which kind of durations of said periodical  
noise duration a transmitting data symbol belongs to.

35. A digital subscriber line communicating system for communicating through a communication line, including:

10 means for generating a sliding window based on a timing signal representing a periodical noise duration;  
means for discriminating, based on a status of said sliding window, which kind of durations of said periodical  
noise duration a transmitting data symbol belongs to; and  
means for performing an initial training of a receiver equalizer according to said status of said sliding window.

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Fig.1A

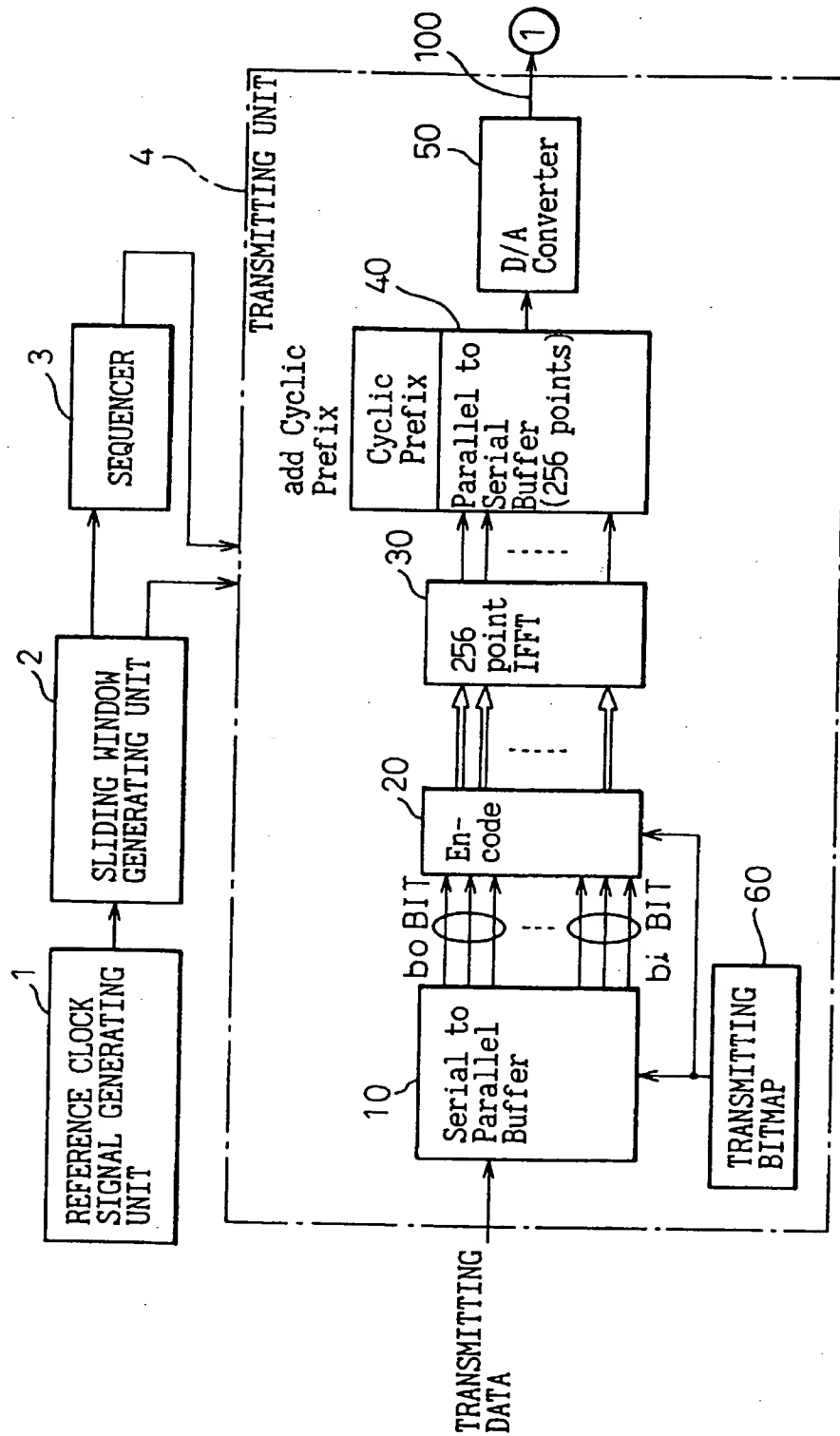


Fig.1B

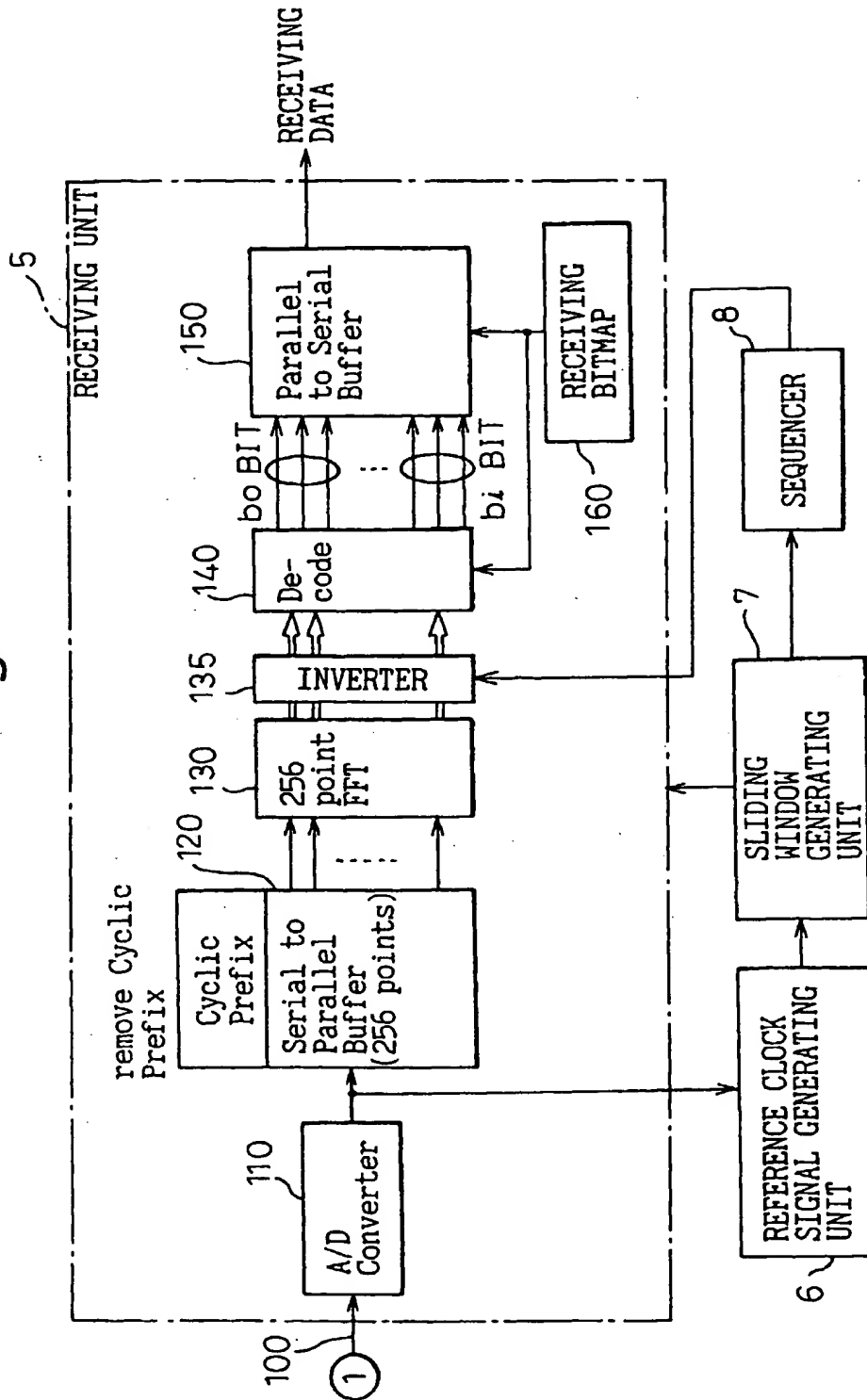


Fig.2

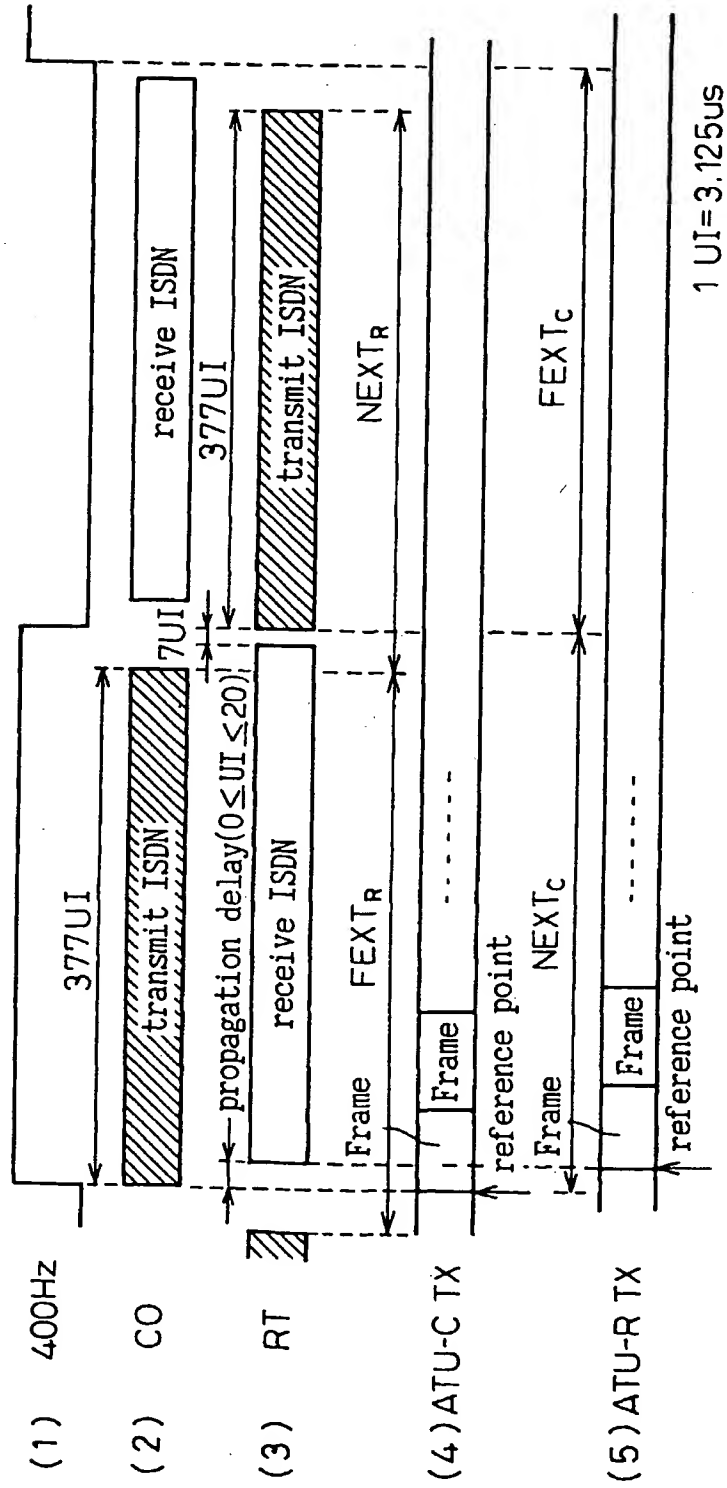
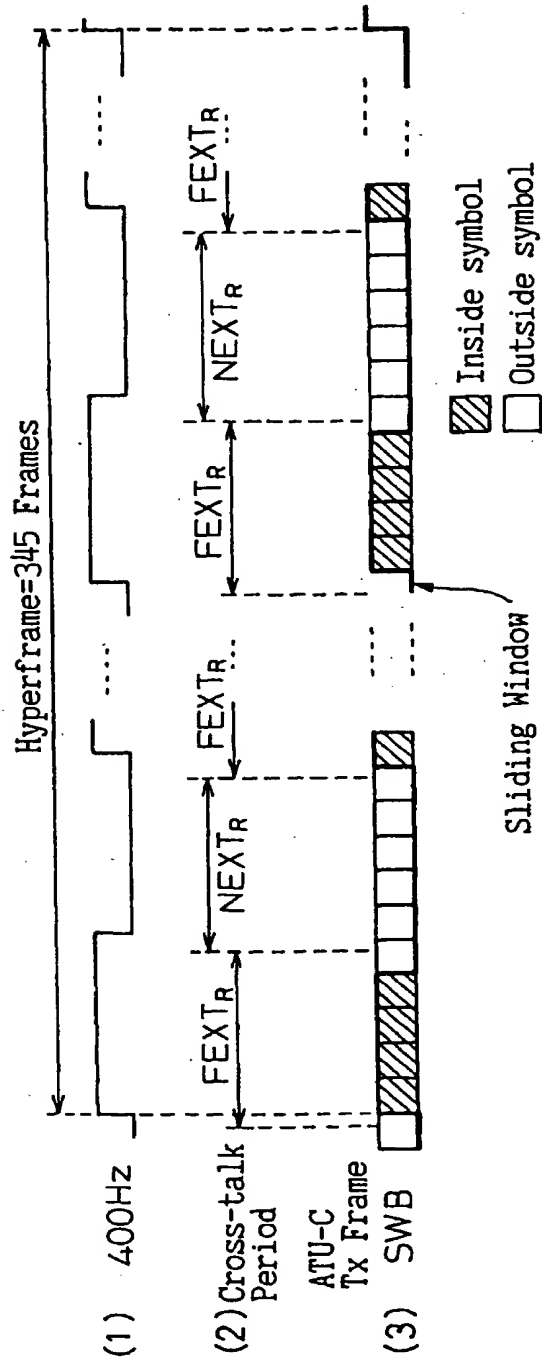


Fig. 3



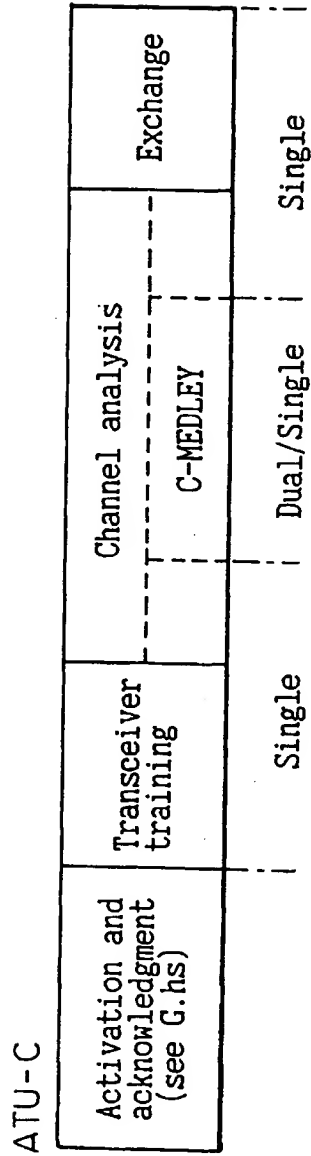


Fig. 4A

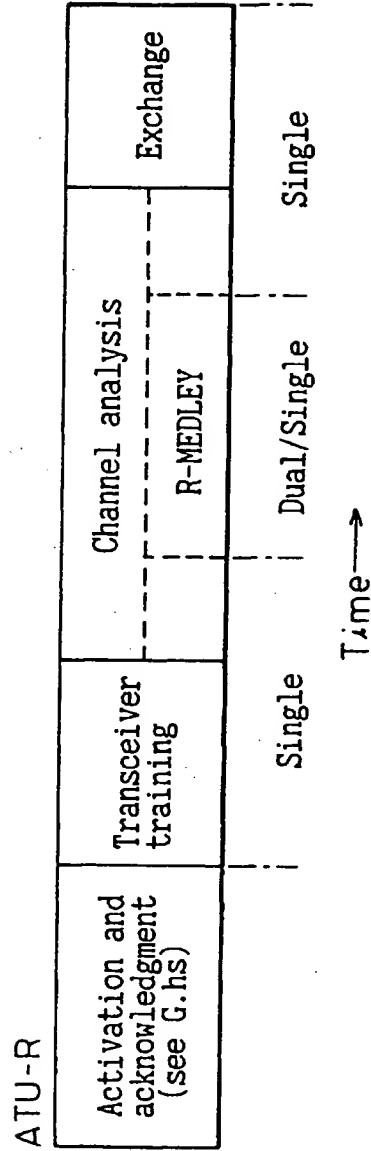


Fig. 4B

Fig. 5

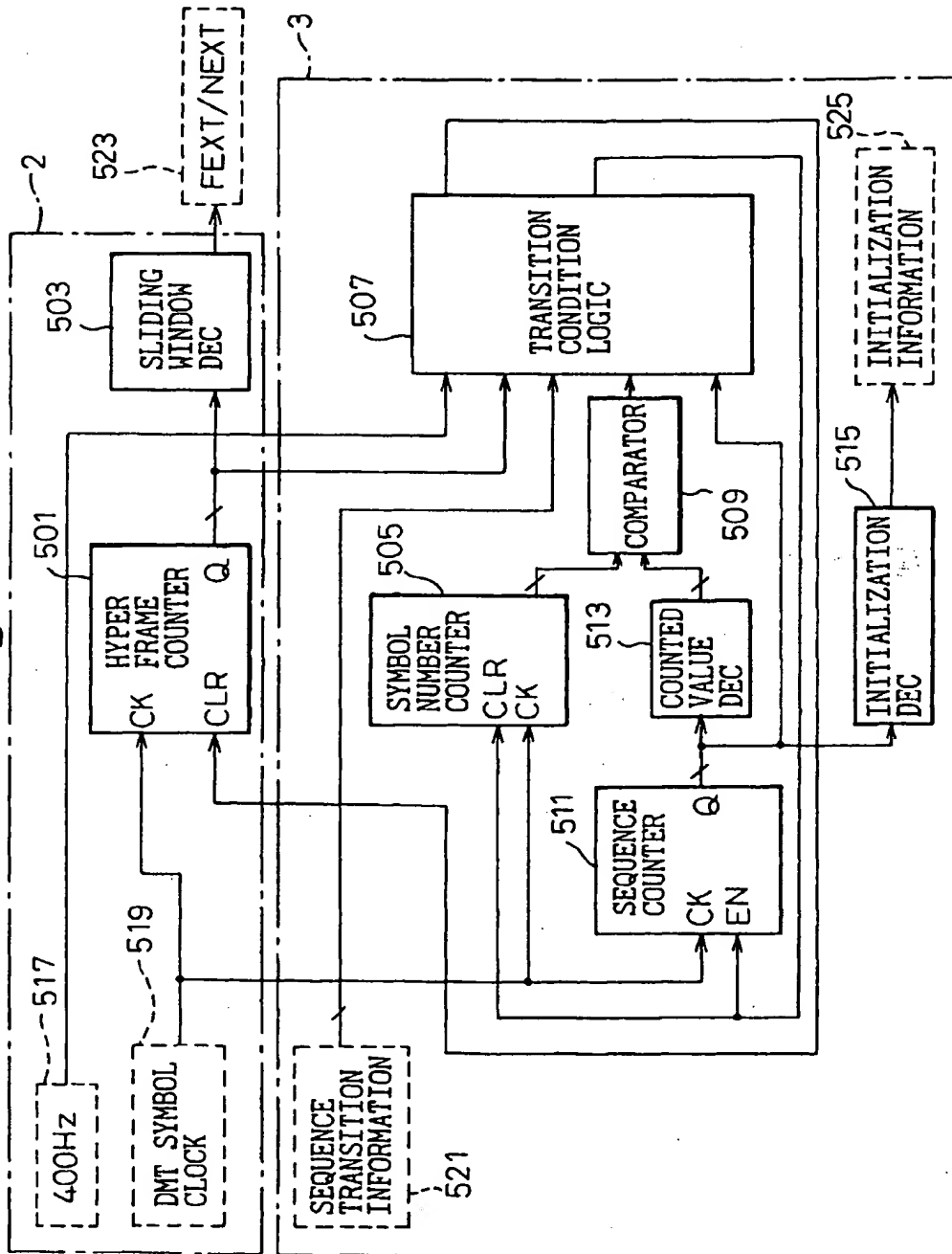


Fig.6

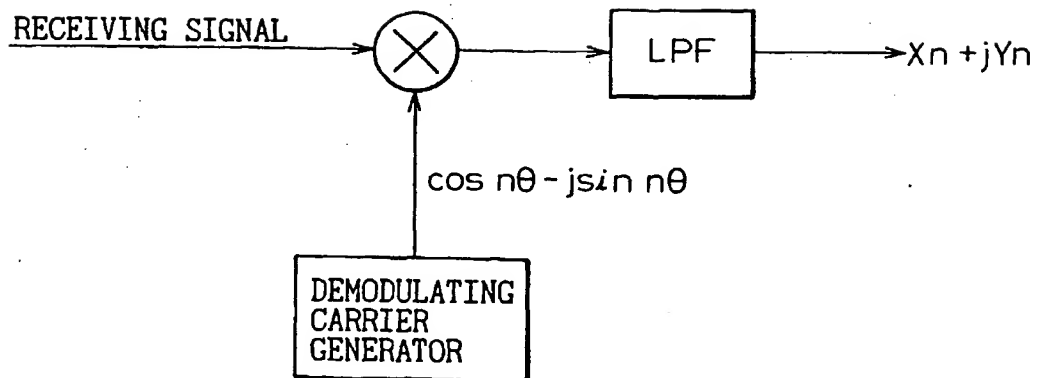


Fig. 7

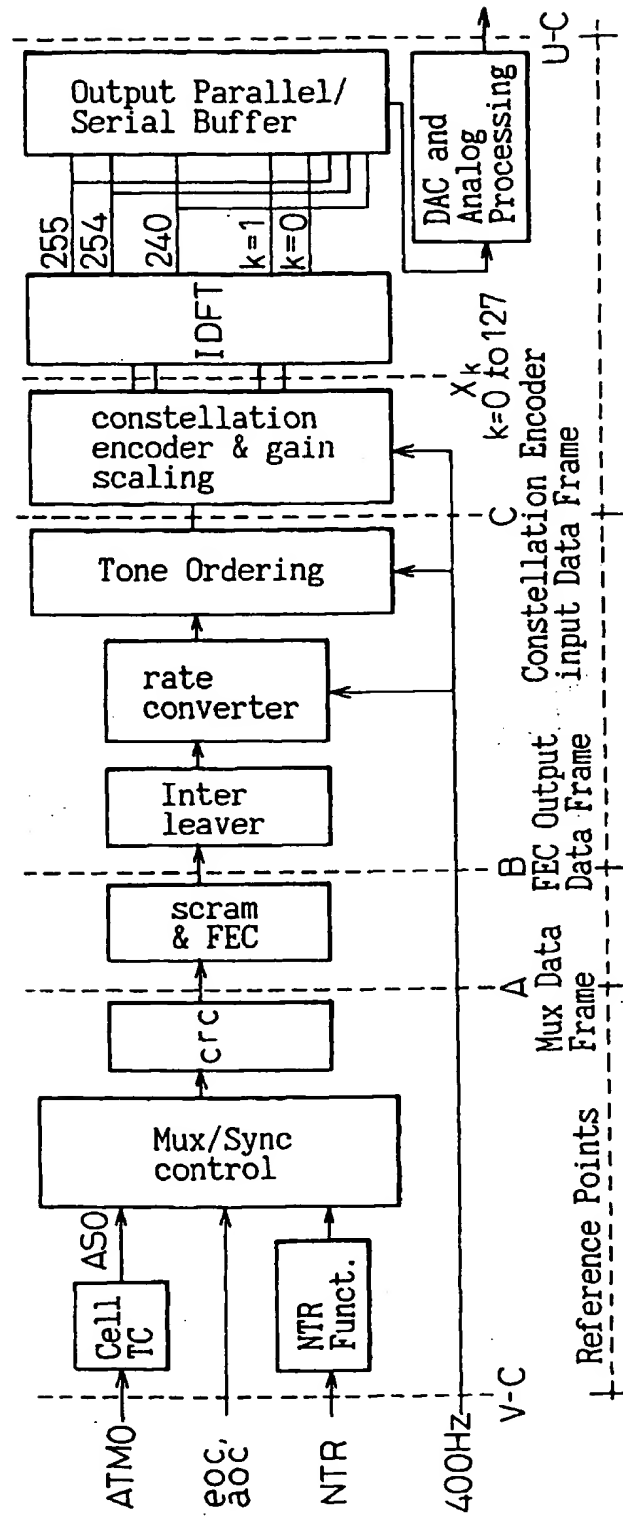


Fig.8

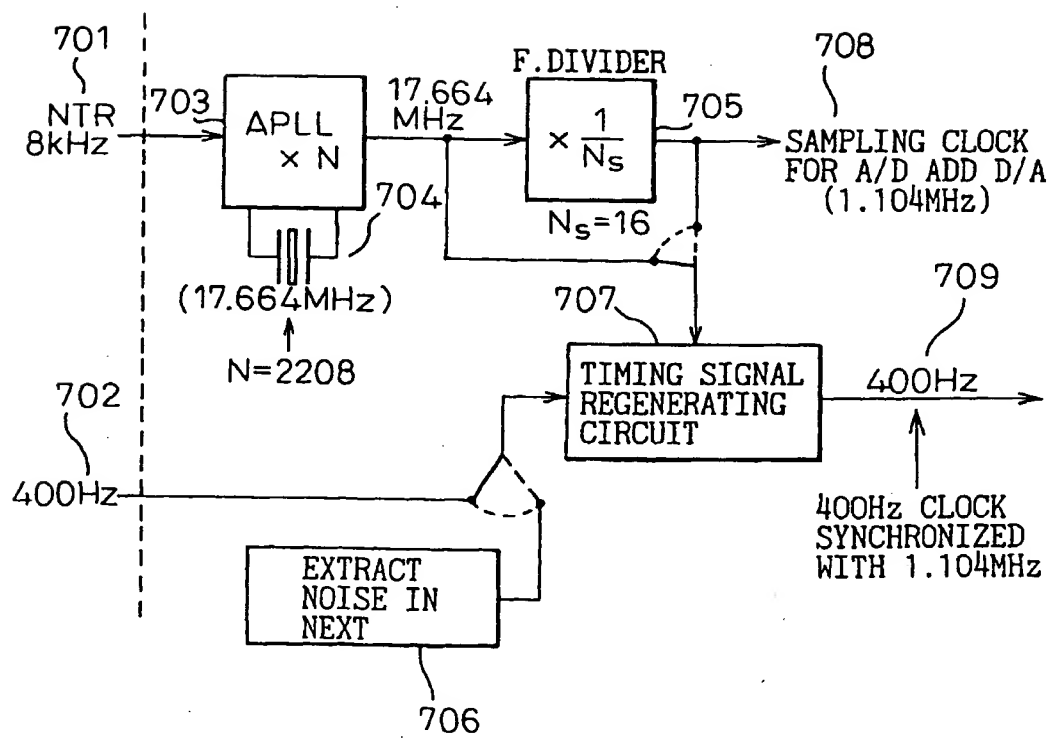


Fig. 9

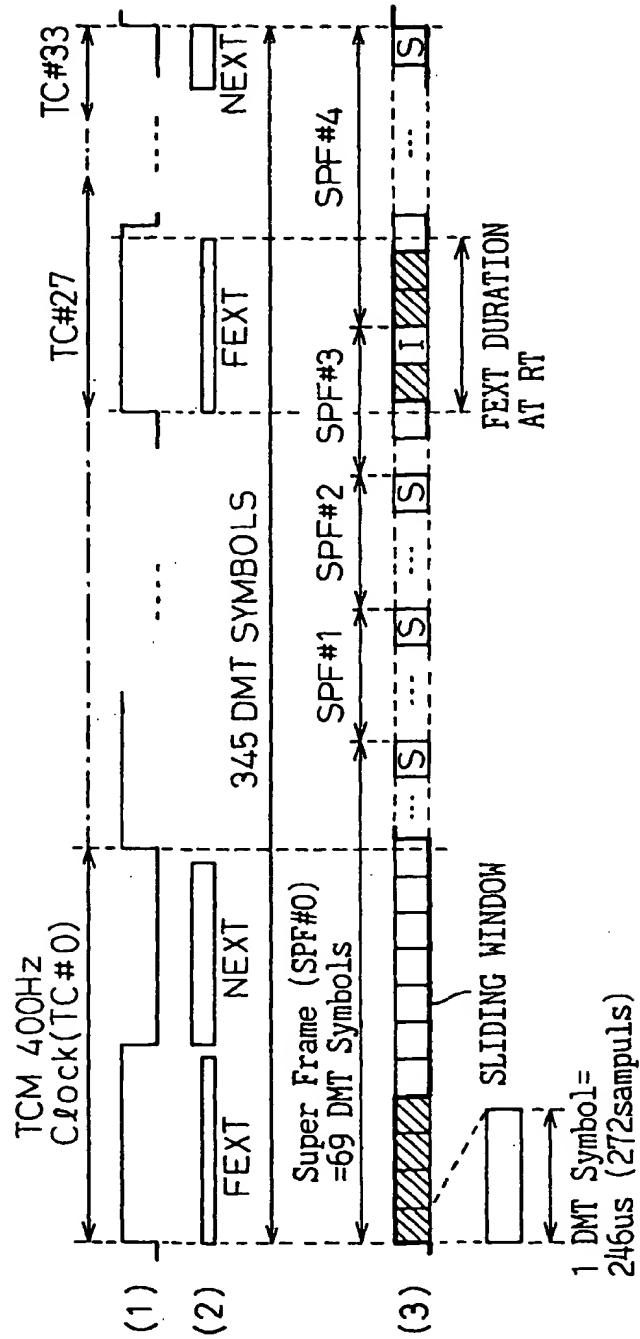


Fig.10

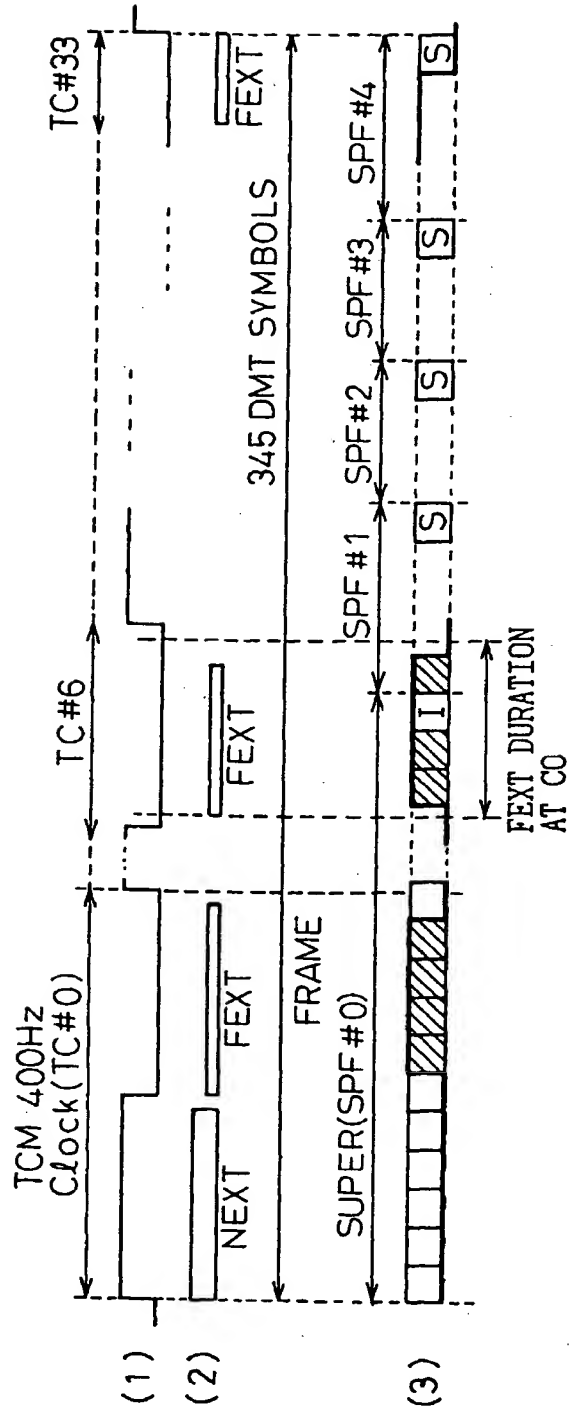


Fig.11

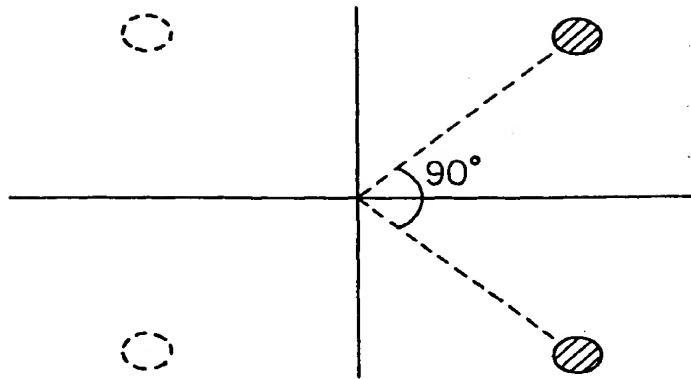


Fig.12

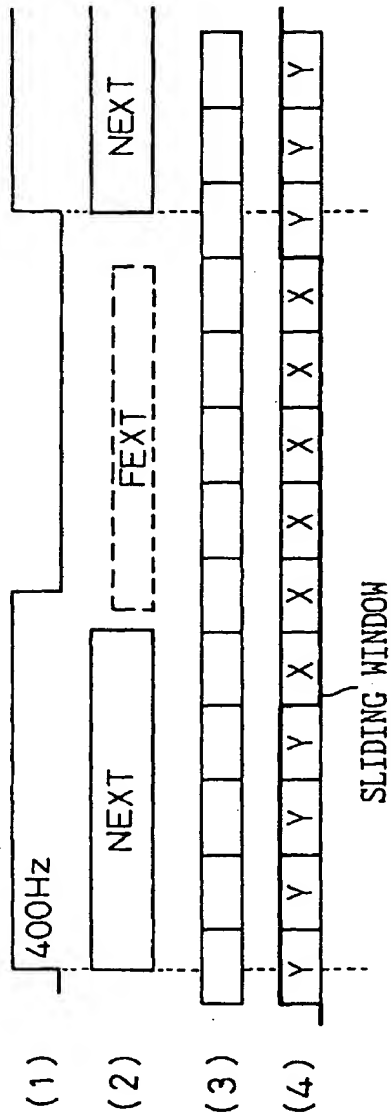


Fig.13A  
PRIOR ART

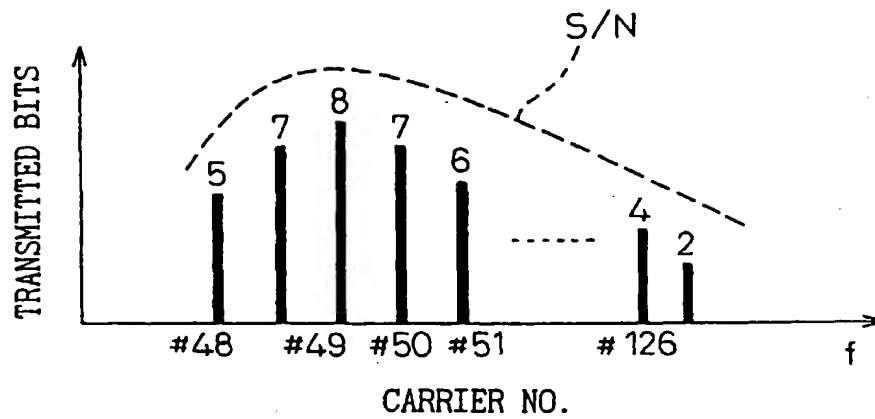


Fig.13B  
PRIOR ART

CARRIER NO. $i$	NUMBER OF TRANSMITTED BITS $b_i$
0	0
$\vdots$	$\vdots$
48	5
49	7
$\vdots$	$\vdots$

Fig. 14  
PRIOR ART

